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THE GREAT LYONS BRIDGE BETWEEN THE HILLS OF FOURVIERE AND CROIX ROUSSE.

THE two Lyonnaise hills of Fourviere and Croix Rousse, both of them populated with thrifty inhabitants, are separated from each other by a chasm, at the bottom of which flows the Saone. To the right and left the plains reach an altitude of 251 and 298 meters. This natural arrangement renders communication difficult between the inhabitants of the two banks. So the idea of connecting the two hills by a great bridge has long occupied the attention of engineers. It would have been impossible to think of such a thing in days gone by, with masonry structures as the sole resource, but now the progress made in metal structures permits of solving a problem of such importance with certainty.

The conception of a great metallic passage way between Croix Rousse and Fourviere, as imposing as it is, embodies nothing to surprise us, and the results hitherto acquired in structures of this kind leave no doubt as to the possibility of the execution. Aside from a few impracticable combinations, two remarkable projects have been studied, and very recently presented, for solving the problem. The mere mention of the names of the authors of these suffices to show that the realization is certain and that it will be brilliant.

One of the projects is due to the Eiffel establishment, and the other to Mr. Clavenad, government engineer and director of public works of the city of Lyons.

We shall give a brief description of each. Let us say at the outset that the work is not solely designed to connect the two Lyonnaise hills by a wagon way, but is at the same time to effect the junction of the line of Bourg with Saint Etienne through the high regions of the West Lyonnaise, and put in direct communication Lyons, Ain, the Jura and Switzerland with the industrial and agricultural regions of the Loire and Saint Etienne. Moreover, from a strategetical standpoint, it presents an interest that cannot escape us. It suffices to take a glance at a map in order to comprehend the services that the junction is capable of rendering to the place of Lyons as well as to the general mobilization, by putting the highest parts in communication. The bridge will therefore connect the lines of Mornant on the one hand and those of Bourg and Trevoux on the other. It appears probable, however, that the line of Mornaut will be prolonged to Saint Etienne through the elevated regions of the Loire, which are deeply interested both in agriculture and manufacturing.

Project of the Eiffel Establishment.—This company has in its annals the great Garabit arch—a brilliant success, and a bold innovation which causes one to always think of it when it is a question of crossing a chasm, through space, on a great extent of iron. The name of Eiffel will always be attached in the future to every grand enterprise of this kind. However, in the particular case that occupies us, it is not an arch that Mr. Eiffel proposes, but a steel superstructure with three continuous central spans of the cantilever system. This system, which is very justly appreciated in foreign countries, and especially in the United States, presents at its upper part a straight line and at its lower part an arch or broken line. The cantilever possesses a static equilibrium. It exactly recalls the structure of wooden frame bridges, which form its constructive point of departure, and to which metal adds resistance and rigidity. Pleasing to the eye, it lends itself admirably to the mechanical conditions of resistance and permits of giving the girders a great height upon the piers, just at the points where moments are maximum.

The Eiffel establishment proposes a cantilever upon mixed piers, of masonry at the lower part and of metal at the upper. It is led to this by several important considerations. In the first place, metallic piers, which are advantageous as regards economy, up to a certain height and for a certain span, become onerous beyond. It is necessary then to have recourse to hollow masonry piers. This solution results from the discussions that took place at the time of the construction of the Garabit viaduct before the council general of bridges and highways. Along with engineer-in-chief Bauby, Mr. Eiffel at this epoch caused the triumph of the solution by metallic piers, while our regretted colleague, Mr. Leon Boyer, sustained the thesis of hollow masonry piers.

From that discussion has arisen the exact definition of the limit to which metal ceases to be advantageous for the construction of piers and must give way to masonry, and inversely.

The project of the Fourviere-Croix Rousse bridge is an interesting confirmation of it.

On another hand, in the case under consideration, an important artistic consideration intervenes. The bridge projected is thrown over a bend of the Saone. Unless we suppose the observer placed very high and very far off, it is certain that he will not be able to see the work in its entirety. Under the most ordinary cir-

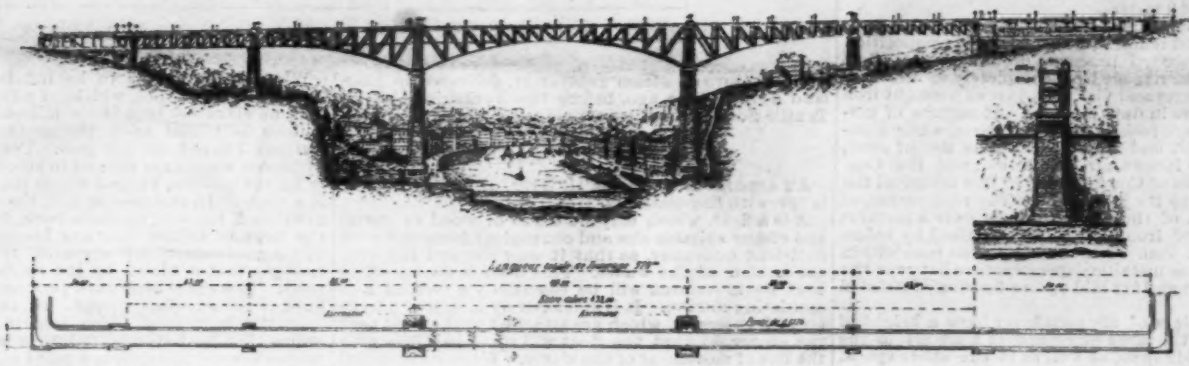


FIG. 1.—LYONS BRIDGE BETWEEN THE FOURVIERE AND CROIX ROUSSE HILLS—PROJECT OF THE EIFFEL ESTABLISHMENT.

FIG. 2.—MR. CLAVENAD'S PROJECT.

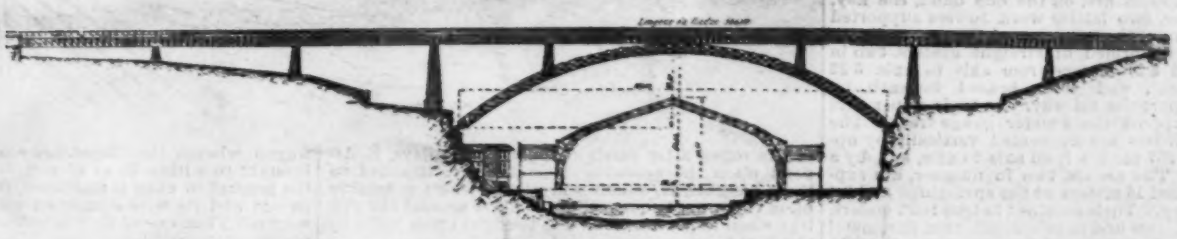


FIG. 3.—ELEVATION OF MR. CLAVENAD'S PROJECT.

cumstances, he will be able to see only a part of the piers supporting the bridge and a portion of the arch supporting the flooring. The artistic point of view, which plays so great a role in the conception and establishment of arches, therefore, here loses a great portion of its very real importance, while in a widely open and clear valley the work of the engineer magisterially encompasses the landscape and completes the aspect of nature by a harmonious testimony of the products of human efforts.

The immediate questions of economy, resistance, and facility of execution, however, dominate the others, and it is to them principally that the attention of our engineers should be directed in this great work, whose principles we are examining.

The cantilever viaduct proposed by the Eiffel establishment (Fig. 1) is to carry a roadway and a double railway track. Its total length is 578 meters, divided up as follows:

Great central span	142	meters.
Two lateral spans of 85 m.	170	"
Two shore spans of 63 m.	126	"
Croix Rousse approach	50	"
Fourviere approach	90	"
Total	578	"

The viaduct, with a gradient of 1·8 per cent., rises on the Fourviere side, and the level of the rail is as follows:

Croix Rousse abutment	237·895
Center of the viaduct	241·750
Fourviere abutment	245·604

The width of the roadway is 6 meters, and that of each sidewalk is 1·375 meter, giving a total width, between balustrades, of 8·75 meters, and a free width of railway tracks of 8 meters.

The metal proposed is soft steel, obtained with wonderful facility and remarkable certainty of composition through the improved processes of metallurgy. Soft steel is tending to replace iron completely in the construction of bridges and viaducts, just as wrought iron replaced cast iron in days gone by. It permits of giving infinitely more resistance to the parts, while gaining on the weight and dimensions. The use of steel, moreover, is no longer an innovation, and the Congress of Processes of Construction in 1889 relegated the domain of iron to its just limits. The road passes, at the upper part of the superstructure, over a metallic flooring of curved iron plates, and is flanked by balustrades of forged iron. The railway tracks pass within the interior of the metallic superstructure between the principal girders and are laid upon a flooring of striated iron plate.

The main girders of the cantilever have a height of 24 meters upon the large piers and of 8 meters in the center of the wide span, as well as in the shore spans. Their distance apart is 8·75 meters from axis to axis. They are of the lattice type. Upon the piers the uprights are of lattice work faced with decorative cast iron pilasters.

There are two large piers, two small ones and two abutments. The piers, as we have said, are of masonry, with an upper metallic part corresponding to the metallic part of the bridge. As this upper part is about the only one that permits of seeing the bend of the Saone, it was of interest to give it as much lightness as possible and to allow plenty of air and light to pass through.

The large piers are 56 meters in height from the level of the landing places to the point of support of the girders. Their cornice is 3·5 meters, and the subbasement is 9 meters. Their section is 20 x 10 meters at the base and 16 x 8 meters at the top. The facing is of rubble masonry, with corners of dressed stone. In the interior of the piers, at one of the sides, is reserved a circular well for the reception of elevators designed to carry pedestrians to a height of 76 meters. On its exit from the masonry the car will be guided by a metallic cage 24 meters in height corresponding to the height of the girders.

The masonry abutments serve as approaches. They carry the railway direct and serve as a support to the columns of the road viaducts.

Mr. Clavenad's Project (Figs. 2 and 3).—The project of Mr. Clavenad responds to the same exigences as the one just described, but it solves the problem by a means radically different from a technical point of view.

Mr. Clavenad proposes an elliptical arch of large size having a span of 214 meters and having three points of support for the viaduct, and the estimated total length of which is 564·165 meters between the abutments. The points of support are, on the one hand, the key, and on the other, two lattice work towers supported symmetrically upon the haunches of the arch.

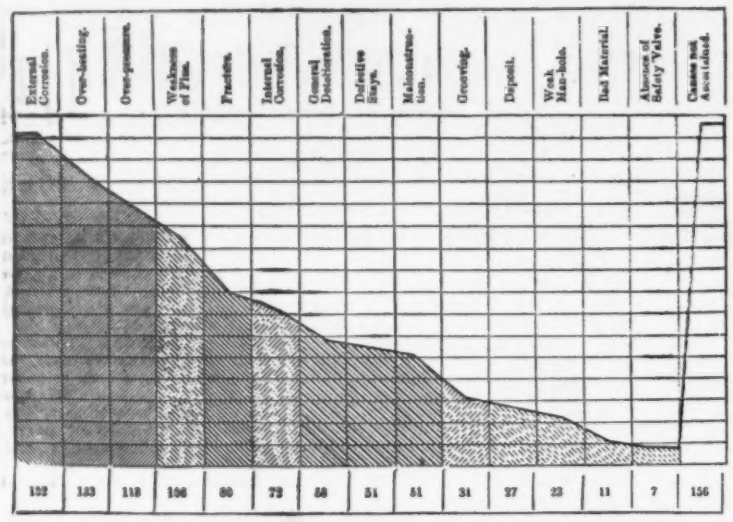
The viaduct is formed of straight girders, two in number, spaced 5·38 meters from axis to axis, 5·32 meters in height, and cross braced beneath by pieces that support the railway. At their upper part these girders support the 8 meter gauge track. The chords of the girders are connected vertically by uprights spaced 2·985 meters from axis to axis, and by a simple lattice. The arches, two in number, are supposed to be spaced 16 meters at the springings and 7·4 meters at the key. Their constant height is 5·7 meters.

The various pieces are so calculated that the metal is at no point made to support a stress greater than 7·6 kilogrammes per square millimeter of section in the straight girder, 12·4 kilogrammes in the arch and 9·5 kilogrammes in the piers. The interesting solution proposed by Mr. Clavenad for this important problem was suggested by the splendid results obtained with the Douro bridge and the Garabit viaduct. Without entering at present into a deep discussion of the projects presented, it is to be presumed that, although the Eiffel establishment has in the present case abandoned a system that it was the first to apply, it is because it has thought that, for the crossing of the Saone, a different system might present more economical and advantageous features.

The site of the projected bridge is such that it seems impossible to embrace in its *ensemble* any work whatever, superstructure or arch, thrown between the two hills. It follows that the use of the arch loses in this case its *raison d'etre* in so much the more that its establishment, in consequence of the difficulties of putting in place, would carry with it an increase of expenses.—*Abstract from Le Genie Civil.*

THE CAUSES OF BOILER EXPLOSIONS.

The accompanying diagram shows graphically the causes of 1,079 boiler explosions, and is based upon an analysis of available reports of boiler explosions over a series of years. It was prepared by Mr. B. H. Thwaite for his lecture on steam generators, delivered in England a short time ago, before the Yorkshire College Textile Society; and we reproduce it from *Industries*.



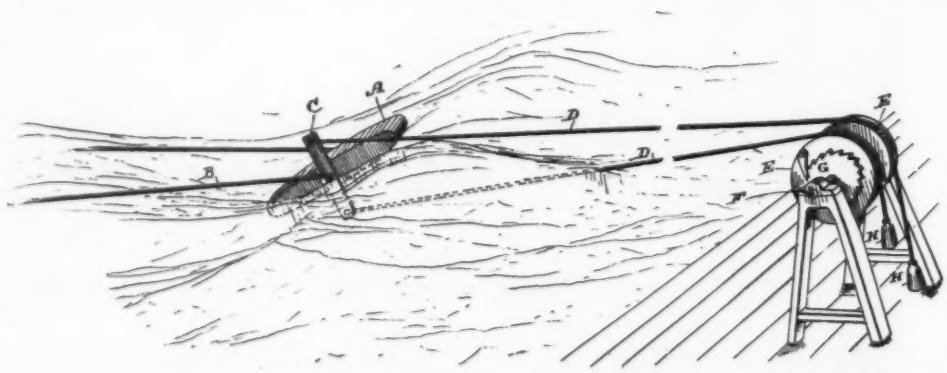
NUMBER OF EXPLOSIONS FROM THE CAUSES ENUMERATED ABOVE.

WAVE POWER APPARATUS.

An apparatus by James M. Dyer, of San Francisco, is herewith illustrated.

A is a float, which may be made of wood or metal and of any suitable size and convenient form and with sufficient buoyancy, so that it may rise and fall with the motion of the waves. This float is anchored, so that its movement will be essentially a vertical and oscillating motion. It is anchored by means of a hawser or hawsers, B, which are attached to the float near the center, so that the float will stand in a line with the line of movement of the waves. When constructed in this manner, the float is of such a length that one end will be raised by the wave while the other sinks into a depression between two adjacent waves, and in this way the float will be caused to oscillate, each end alternately rising and falling as the waves pass beneath it.

C is a frame-work fixed to the float and extending transversely across the points where the anchoring hawsers connect with the float, so that as the float oscillates upon the waves this frame-work will be caused to oscillate in unison with it. From the opposite ends of the frame-work, C, the ropes, D, extend to the shore or to any suitable structure which is situated at a considerable distance from the float, so that the connecting ropes, D, extend approximately at right angles from the frame-work, C. These ropes pass around the drums, E, which are mounted upon the shaft, F, turning loosely upon the shaft and having a pawl and ratchet mechanism of any suitable construction, as shown at G, the ratchets being secured to the shaft and the pawls pivoted to the sides of the drums, E. The ends



of the ropes, after passing around the pulleys, E, depend upon the opposite sides and have attached to them weights, H, which will always exert a tension upon the ropes to cause them to move around the pulleys when the strain which is brought upon them by the float is relieved.

THE GRAND MANŒUVRES OF THE FRENCH ARMY.

There is, perhaps, no spectacle more varied and attractive than that of the troops in the grand maneuvers, when they are operating in large numbers on a tract of land where the sites change at every instant, where the ragged, tilled plain succeeds the forest, and where cool valleys spread out at the foot of bare, chalky eminences of desolate aspect. On a bright day, animate these vast and somewhat desert horizons with long columns of infantry, horses, and wagons, and you immediately obtain, by the diversity of the uniforms, and by the multiplicity of the movements, an uninterrupted succession of pictures often full of color and charm.

Military Aerostation.—Here, for example, we have the campaign balloon. A wagon with windlass carrying the wound-up cable which allows the balloon to ascend and hauls it down again, a wagon containing spare pieces, three hydrogen wagons, and a baggage wagon—such is the *materiel*. Nothing less cumbersome could be found. As for the *personnel*, that consists of a captain, a lieutenant, and sixty men, forming part of the companies of balloonists which are under the direction of the engineer corps.

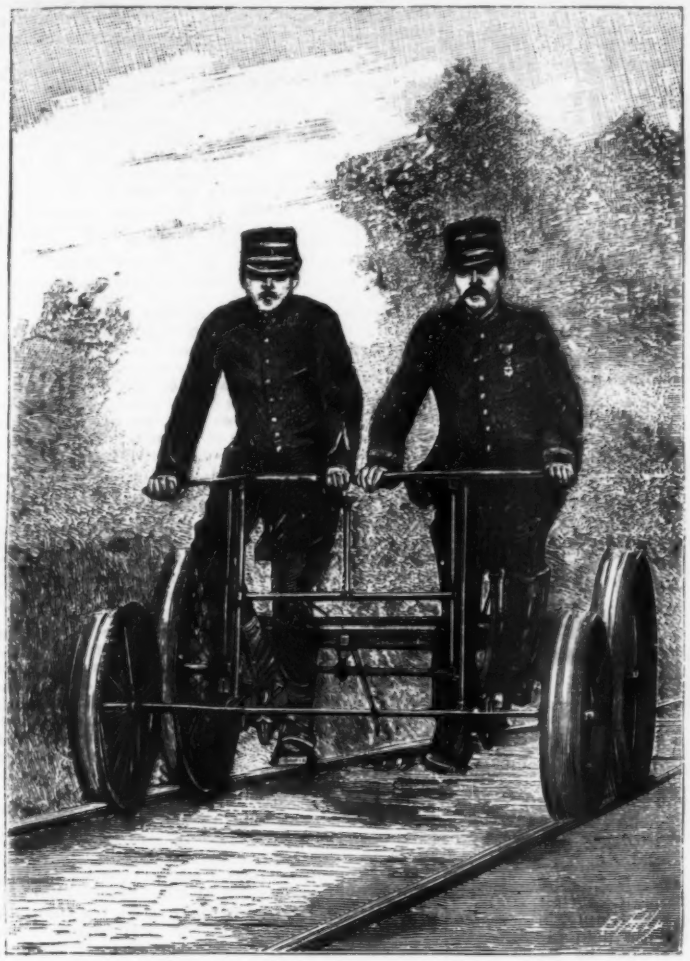
When the balloon is to be inflated, the captain selects a favorable spot, which, as a general thing, is behind an elevation that hides it from the enemy. The balloon is placed upon the ground, and each man stations himself at his post. The cylinders of the hydrogen wagon are opened in succession and gradually fill the balloon, around which the men are arranged in a circle. In measure as the gas causes the balloon to expand, the soldiers move back, from mesh to mesh, the bags of ballast that are hooked to the netting. These movements are executed to the sound of a trumpet that is blown by the lieutenant of the company. The car is afterward produced, and the cable is fixed to the windlass wagon. In twenty minutes the operation is finished. The captain, according to the orders that he has received, then sends the windlass wagon toward the assigned point of observation.

The campaign balloons usually have a capacity of 1,200 cubic meters, and are capable of lifting two persons—the captain of the aerostatic park, who is in command of the maneuvering, and the officer whose duty it is to scan the horizon. The length of the cable is 500 meters.

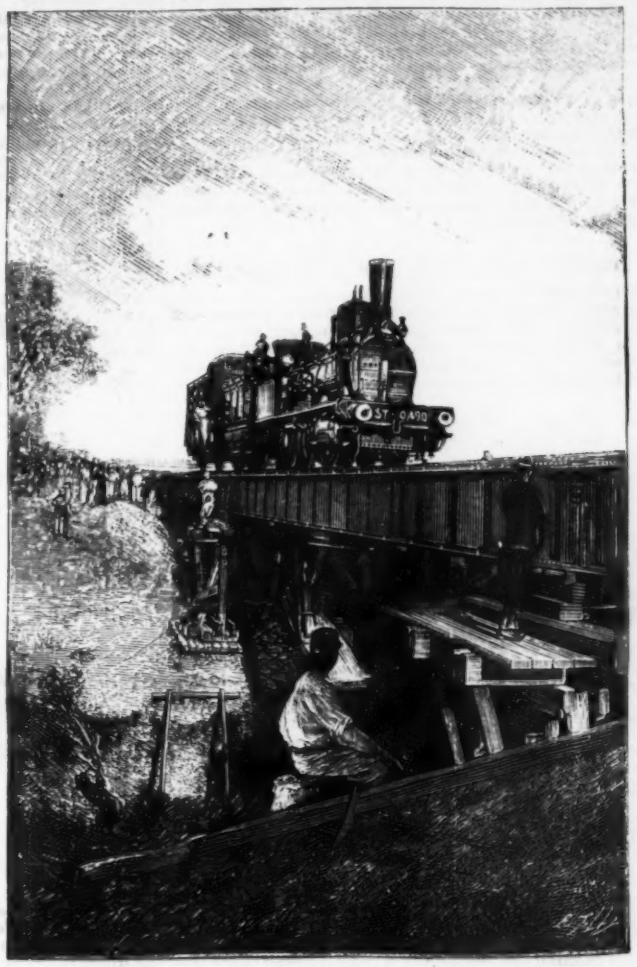
The Telephone of the General in Chief.—It is not sufficient that the general in chief shall see, and give his orders at a short distance; it is necessary also that he shall hold himself in constant communication with his lieutenants, however distant they be. Military telegraphy affords him the means for this, but, since the transmission of dispatches requires a certain length of time, the idea has occurred to complete or to replace the telegraph by the telephone. The apparatus that has been tried this year, and has operated perfectly, is due to the researches of the army engineer corps and of the engineers of the administration of telegraphs. It consists of a box 30 centimeters square, which contains a transmitter, two receivers and a microphone call. As shown in our engravings, the telegraphic wagon whence the dispatches are transmitted being brought to within 30 or 40 meters of the place where the general in chief is stationed, the telephone is taken out and its wire connected with the cables of the wagon. Then one of the aides-de-camp takes the telephone, stations himself alongside of the commandant in chief and sends his orders to a distance, and the information received from the other generals with whom telephonic communication is established is repeated to him.

A Marcille Bridge.—The services already rendered by the regiment of railway sappers under certain circumstances where it has become necessary to proceed to the reconstruction of bridges with rapidity have certainly not been forgotten.

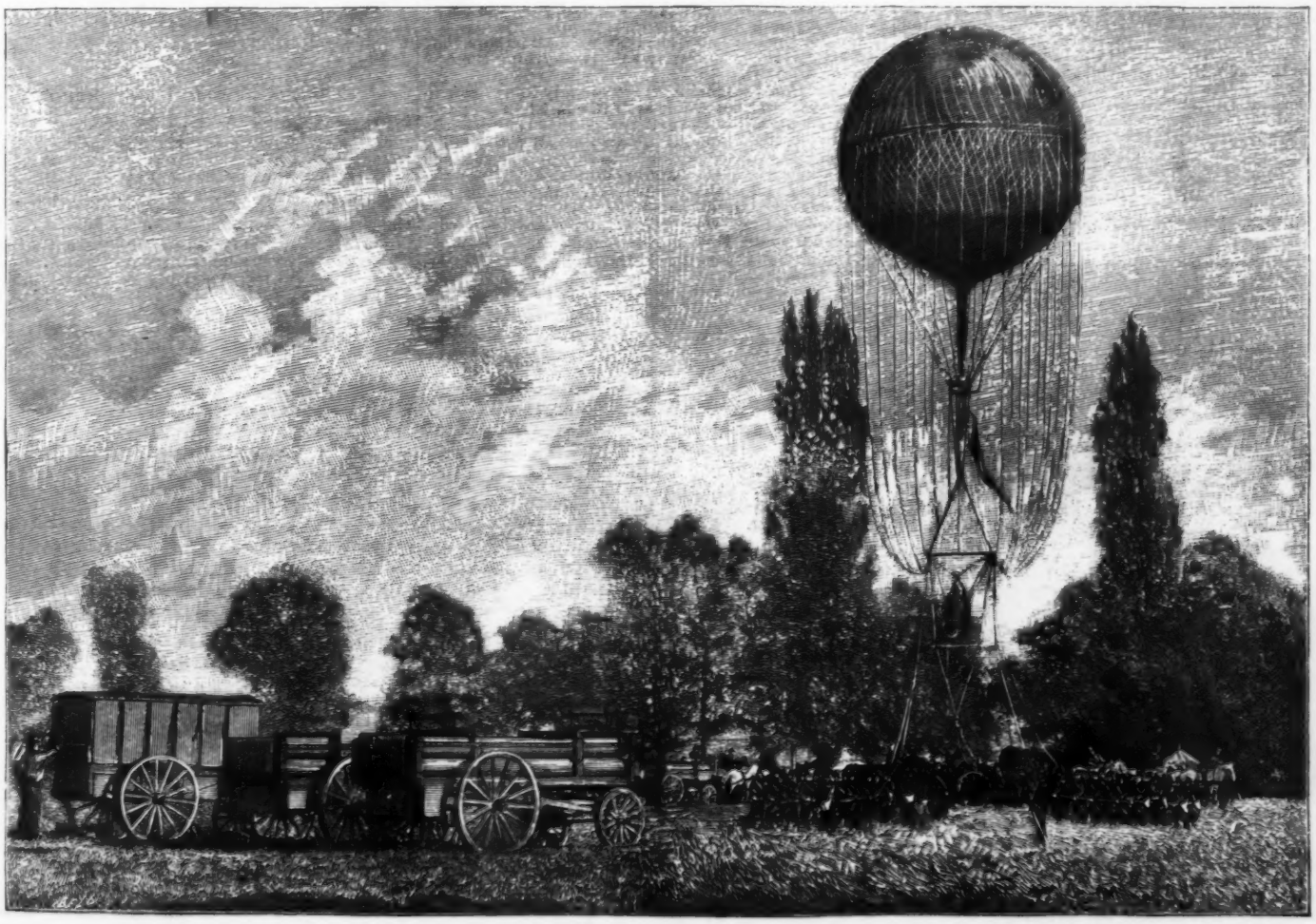
In order to make sure that the repairs could be effected well and quickly, it was supposed that the enemy had destroyed, at the station of Mathaux, near Brienne, the 45 meter bridge thrown over the Aurance, and an order was given to a company of sappers of the railway regiment to replace it by a bridge of the Marcille system. The track was begun on the 5th of September. The bridge, which had been taken from the docks of the military railways at the proving grounds of the Matelots station, near Versailles, arrived on the 8th. On the 12th the bridge was in place, and the railway sappers were finishing the junction line of the



(1) Reconnoitring on a railroad line with a quadricycle.



(2) Bridge built on the Aurance by the auxiliary company of railroads.



(3) THE GRAND MANŒUVRES of the French Army. Aerostatic park attached to the general staff of the army.

new bridge with the railway upon the two banks of the Aurance. Upon the same day two soldiers upon a quadricycle passed over this junction, which had been formed in adopting curves and profiles of maximum limit, in order to still further increase the difficulties. Then a locomotive made a second reconnaissance of the track amid the plaudits of the soldiers, who saluted the captain in charge of this fine work. Finally, on the 13th, a train carrying a load of eighty tons ran from Brienne to Troyes over this new road.

It took eight days to finish this fine work, but only half of the workmen necessary had been employed. With double the number of men four days would have sufficed.—*L'Illustration.*

PHOTOGRAPHY UPON A BLACK GROUND.*

The terms of the problem laid down in our preceding article were the following: to find a process for limiting the field of an objective to any one of its fractions whatever, so as to preserve intact, for subsequent exposures, the unused portion of the sensitive plate, and to be able to obtain upon the latter such combinations as may be desired of any number whatever of successive poses.

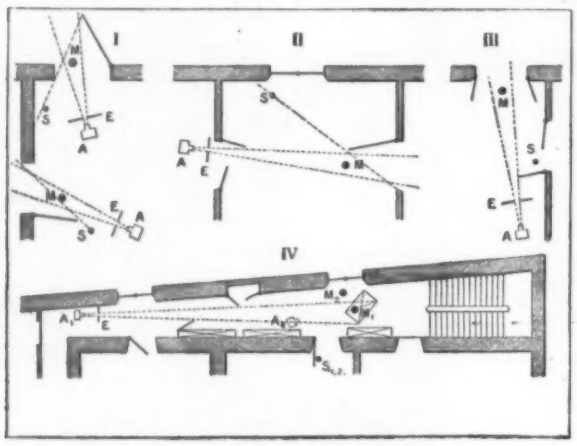


Fig. 1.—EXPLANATORY DIAGRAM.

Now, a very simple geometrical construction, and simple calculation, the details of which I shall spare the reader, prove that if we call D the diameter of that portion of the field, M, that we wish to allow to be seen through the objective (or more accurately the excess of such diameter over that of the objective), L its distance from the apparatus, and H its mean height (or the distance from its center) with respect to the optical axis, we can always, by placing at a distance l, and decentering by a quantity h, a screen containing an aperture whose diameter exceeds, by d, that of the objective, so contrive that all the luminous rays coming from the part, M, of the field, and these alone, shall reach the objective integrally and give their image in the camera absolutely as if there were no diaphragm interposed.

It suffices for that to satisfy the relation

$$\frac{D}{d} = \frac{L}{l} = \frac{H}{h}$$

which can be done in an infinity of ways by varying either the distance, l, or the diameter, d, of the diaphragm screen. But it must not be thought that the choice is so indifferent in practice, for there is reason for taking account of the zone which remains visible in penumbra all around the field for a width of $\left(\frac{L}{l} - 1\right)$ diameters of the objective, and which, upon the plate itself, gives a degradation of $f\left(\frac{1}{l} - \frac{1}{L}\right)$ times this same diameter. It will therefore be necessary to choose for l (that is to say, for the distance of the screen) values sufficiently great to prevent the extent of the degradation from working to the prejudice of the junction operations that we have more particularly in view.

But this restriction cannot be an inconvenience, since it suffices to increase proportionally the diaphragm, d, and we shall no longer know any obstacle if we succeed in arranging a screen of which the surface turned toward the apparatus remains so dark as to have no sensible effect upon the plate. To construct a movable screen is not a difficult thing to do. It suffices to fasten, with two drawing pins, a piece of cloth or a sheet of paper between two laths nailed vertically against the sides of an old box, which, loaded with stones, will serve as a foot. In front of a large aperture formed in the sheet will be pinned other and smaller paper diaphragms, and this will do away with the necessity of displacing the large sheet in totality for regulating.

As for the final regulating, it will not at all be expedient to recur to the formula and endeavor to solve equations. The conditional equalities that we have stated may, in effect, signify very simply, in common language, that the contours of the field and those of the diaphragm and objective should be found upon the same surface of a cone, that is to say, all three should be on a level with a string stretched through the aperture in the screen from the edge of the objective lens to the extreme field that it is desired to photograph. The eye, that excellent geometer, is perfectly capable of replacing the string, and when, on viewing extreme points of the field, it is found that the corresponding points of the diaphragm and objective are seen upon the same straight line, we shall be sure that new tentatives are useless and that everything is ready to go on all right.

For as regards blackness, we already know how to realize that, and the whole art will consist in properly taking advantage of the arrangements of the places in order to put the screen to the best advantage possible in the shadow of the flash and to shield it at the side of the apparatus against the rays diffused by the walls and ceiling, and which, reaching there, become our worst, our sole hinderance, while, rejected on the side of the model, they serve to give the negatives a softness and a model that, in photographing with magnesium, almost always renders the use of bilateral illumination unnecessary.

Without having recourse to special screens, and despite the necessity (in order to avoid paradoxical effects) of preserving, for the various exposures of the same negative, the same direction of illumination, it will be very rarely that we do not find in a room some combination of doors or windows that can be utilized.

Fig. 2.—COMPOSITE PHOTOGRAPH IN TWO POSES AT DIFFERENT DISTANCES ON THE SAME PLATE.

In diagrams I. to III. of Fig. 1 we show arrangements that are quite frequently met with, and in diagram IV. the exact plan, to a scale of $\frac{1}{100}$, of the arrangement that has permitted us to take a number of photographs analogous to the one reproduced in Fig. 2, where a kneeling girl is represented as a statuette upon a table. Operating without any aid aside from the motion of the hand that holds the bulb, we, to the great prejudice of æsthetic effect, placed ourself in the field, in order to well show to the incredulous that the relatively long time of the opening of the objective that was required either in this displacement or in the first exposure did not produce the least appearance of a veil upon this scene, which was illuminated from time to time by a powerful kerosene lamp and a candle situated very near each other.

Moreover, should a veil exist, it would not, if uniform and light, greatly injure these sorts of photographs with marked contrasts. This is proved by Fig. 3—a reproduction of a photograph taken at the beginning of our experiments under peculiarly rudimentary conditions. We operated in open daylight in a village place, using as a black background the opening of a large coach house to the north. As a screen we used a piece of blackened cardboard supported by a violin stand that may be seen to the right of the figure. Now, if we closely examine the child who, in front of the cart, is assisting in the delivery of his own head, we shall find that it is traversed vertically by a line of shadow, indicating that a slight veil was produced at the first exposure upon all that portion of the plate that was exposed by the incompletely drawn shutter of the frame. If the plate had been entirely exposed, it would be difficult to suspect anything. Per contra, a still minuter examination of the figure allows to be seen at the top of the head, besides a diminution of intensity (which proves that the model had moved slightly into the zone of penumbra), a few blotches, which are nothing else than the inequalities of the poor cardboard, smeared with ink, used as a screen. How can it be supposed, in fact, that the latter, had it been of a perfect blackness, would not have been able, illuminated by the full light of day, to make an impression on the entire plate? The same accident must occur in night operations whenever we do not succeed in sufficiently protecting the posterior face of the screen against every actinic ray. And as, on account of that, it might seem hard to give up these amusing experiments, one will have to think of having recourse to some special apparatus, to a new accessory, in order to satisfy all exigences, and to put practice in accord with theory in all cases. This is a *desideratum* easily fulfilled, since it will evidently suffice to unite the diaphragm with the objective by a black tube, either rigid, with a drawing and decentrating motion, or of a fabric in the form of a cone or bellows, fixable to the base of the apparatus by a jointed and lengthening arm.

But to dwell upon this would be to carry us too far from the starting point of this article, and we prefer to await an opportunity of adverting later on, if there is reason for it, to the application of the degrading nigrocone, having had at present no other idea than to offer our readers an unpublished chapter upon physics without apparatus, or at least without new apparatus, since it is assuredly permissible, seeing the rapid extension that the magnesium light has given photography for the past year, to presume that there is not an earnest amateur who is not already provided, in addition to his camera, with some one of the photogens of commerce, or at least with our photospire, which is perhaps somewhat forgotten, doubtless on account of the fact that it is too easily made and costs nothing.—*A. Guebhard, in La Nature.*

SUGAR MAKING BY THE DIFFUSION PROCESS.

The Sugar Experiment Station.

Dr. Stubb's Report.

Since our last report of work performed in the sugar house, the station has been removed from near Kenner to Audubon Park, New Orleans. An iron sugar house, 40x100, with numerous openings for ventilation, had recently been erected for the reception of the machinery from Kenner. This house being much larger than our old sugar house permitted the rearrangement of the machinery and its adjustment in such a manner as experience had determined best suited to our wants. Mr. Jno. Paul Baldwin was placed in charge of its erection, and so well was his work performed that little or no difficulty was experienced during the entire campaign.

Fig. 3.—GROUP IN OPEN AIR IN TWO DIFFERENT POSES ON ONE PLATE.

In the boiler house, 30x60 feet, 20 feet from the sugar house, are two boilers of sufficient size to furnish an abundant supply of steam for all the operations of the sugar house. The sugar house completed may be thus summarized: The cane is conveyed by a carrier to an ensilage cutter with four knives 14 inches in length, and there cut into pieces of ¾ inch to 1 inch in length, and elevated by another carrier to a fan and shaker, when all the leaves, trash and dust are removed. This cutter and its carriers were made by the E. W. Ross Company, of Springfield, Ohio, and by them donated to the station. The gearings of the carriers were not sufficiently strong for the heavy work which it was sometimes found necessary for the cutter to perform.

* Continued from Supplement, No. 818, page 13069.

This was especially true in handling some of the large foreign cane, this year worked for the first time. Otherwise the entire apparatus worked well, and replacing the linked belts with larger ones will, it is thought, give entire satisfaction in future work. The fan is entirely similar to those used for cleaning wheat, rice, etc. Six paddles were arranged for in the construction of the machine, but in practice it was found that four were sufficient to perform the required work. The shaker was this year changed from a horizontal to a vertical motion, and gave good results. The ensilaged chips, cleaned by the fan and shaker, were dropped into a box, from which an endless screw conveyed them to a comminutor. The latter is an invention of Mr. M. A. Swenson, and was made and presented to the station by the Fort Scott Foundry Company, Fort Scott, Kansas.

This comminutor had eight knives, and when not overfed did excellent work. Its capacity was, however, not as great as the ensilage cutter, and great care had to be exercised in feeding the latter, so as to prevent an overfeed and choking of the former. From the comminutor the chips were elevated on a trough by small drags attached at regular intervals to an endless link belt chain. From openings in this trough, over each cell, the chips are conveyed to the battery. The diffusion battery consists of 14 cells, each 47x28 and holding 13·56 cubic feet. It is a double line battery and has a maximum capacity of two tons of cane per hour. Diffusion batteries are located in a straight line, in a double line or in a circle. The number of cells used are from 9 to 16. It has been shown by a local experiment that 9 to 10 cells, when properly worked, are abundant for good work. (See bulletin 23, pages 349 and 350, of this station.) Sometimes double line batteries are worked as two batteries. This method gives increased time for diffusion.

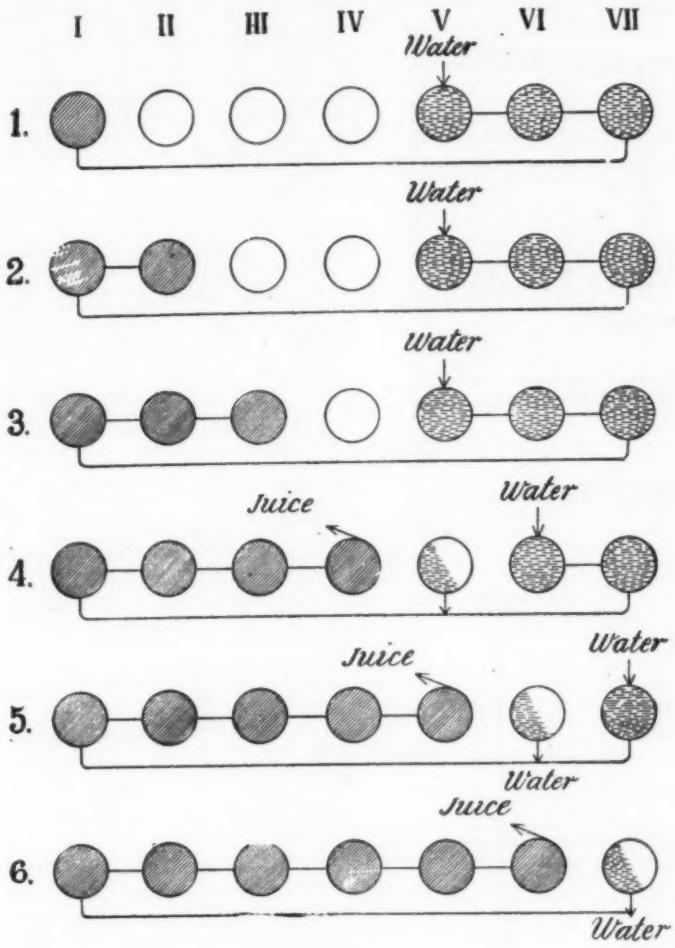


PLATE I

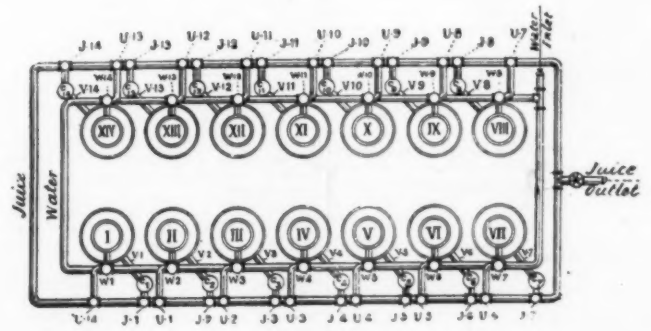


PLATE II.

EXPLANATION OF DIFFUSION BATTERY.

A diffuser is an iron cylindrical cell, made to close tightly at the bottom and top and supplied with pipes below and above. Nine or more of these cells are connected and called a battery. Believing that the diffusion battery will ultimately be the chief, and, perhaps, the only method of extracting juice from the cane, and that at present the chief objection to its use may be found in the ignorance of properly working it, it has been deemed proper to here insert several diagrams, by which the battery and its proper working may be easily understood.

In Plate I is seen a single line battery of seven cells, in the actual conditions which obtain from the filling of first cell till the battery gets in regular working order. The arrow shows the water entering, and finally the juice departing to the measuring tank or weighing machine. Fig. 1 shows the condition of battery when first cell is filled with chips. Fig. 2 when two cells are filled. Fig. 3 when three cells are filled, etc. The horizontal shading means filled with water; the diagonal lines, chips; and the rest are empty.

Plate II. gives a plan of our battery with its cells, calorisators, pipes and valves. The cells are numbered from I. to XIV.; the water valves, W to W14; the juice valves, J to J 14; the valves connecting juice and water pipes, U to U14; and the calorisators or heaters, C to C14.

In the beginning of work, the last three or four cells on the battery are filled with water and heated before being drawn on to the chips in the first cells.

In our sugar house, a large heater disconnected with the battery aids in heating the water in its passage from the water tank in the roof of the house to the battery.

PROCESS OF WORKING THE BATTERY.

As soon as the machinery is in motion and the chips begin to fall into cell No. 1, the last three or four cells are filled slowly with water, heating it in its passage through the calorisators. The water comes from the water tank directly through the big heater and then through tube W and valve W12 into diffuser XII. from above; passes V12 to C12 and ascends the heater and on through the valve J12, through U12, over W13 into cell XIII., then on through V13, C13, over J13, through U13, over W14 into cell XIV, thence into V14 and C14, travels the short distance from J14 to J1 in the juice pipes and runs into C1 from above, passes V1 and ascends into cell I from below, upward through the first chips. As soon as the fluid has reached cell I the diffuser is closed, the air cock opened and kept opened until the water begins to come through, when it is closed.

While water is entering I, which should be done slowly to permit of its being heated "in transitu" through the waters, cell II is being filled with chips. When filled, the water entering C_{14} passes over J_{14} through U_4 over W_1 into cell I from above, driving the juice through V_1, C_1, J_1, J_2, C_2 and V_2 into cell II. This process is repeated until you wish to draw juice from the battery. Suppose it is desired to draw the juice from cell IV. The juice now goes from C_{14} over J_{14}, through U_{14} over W_1, through I, V_1 C_1 over J_1, through W over W_2, through II, V_2 C_2 over J_2, through W over W_3, through III, V_3, C_3, J_3, J_4, C_4, V_4, and ascends into cell IV through the fresh chips. As soon as all the air is expelled from this cell, the valves from C_3 are changed. The juice now rising in C_4 goes over J_4 through U_3, over W_4, through IV, V_4, C_4, J_4, and leaves the battery at J to enter the measuring tank or juice weigher.

This work is continued until sugar work is reached. From now on in our work one cell is being emptied while the other is being filled with chips. Before emptying a cell the entire water in the battery is driven forward, one cell by applying air pressure to the cell to be emptied. In this way the chips are released of much of their superabundant moisture. Before emptying a cell it is completely isolated from the rest of the battery. As a general rule, the juice should enter every cell *from above except the one just filled with chips, and this invariably from below*, to drive out the air and prevent the accumulation of foam and steam in the cell. The temperature is controlled by the valves leading from steam pipe to calorisators.

REQUISITES FOR GOOD DIFFUSION.

1. Fineness of chips. To obtain this, the knives must be kept sharp and must project beyond the cylinder as little as possible to perform good work. With our common canes a projection of one-sixteenth of an inch gave a most excellent chip with rapid work, while many of the larger foreign canes, on account of their softness, could not be comminuted at all with this projection. To perform good work, the knives had to be given a projection of at least one-eighth of an inch. The solidity of the canes determines the projection of the knives, and to a large extent the size of the chip. It may be assumed that the finer the chip, *ceteris paribus*, the better it diffuses.

2. Heat is essential to excellent work. How far a high heat may influence other extractive matter detrimental to crystallization and good clarification is a question yet to be definitely solved. For a high extraction of sugar by diffusion, heat as high as can be obtained is requisite.

3. With the above conditions secured, the time of diffusion can be greatly diminished. With a coarse chip and low heat, even a long diffusion fails to accomplish complete extraction. Time, then, is an important essential of diffusion.

BALDWIN'S JUICE WEIGHER.

From the battery the juice was discharged dually into the "juice weigher." This juice weigher was adjusted to weigh 365 pounds of juice, and direct tests of the machine, made seventeen different times, showed variations from 364 pounds to 367 pounds, with an average of 365½ pounds. This juice weigher performed its part excellently in the early part of the season, as was shown by constant checks and measurements and weighings. Three weeks of constant use, however, without attention caused an accumulation of viscous matter on the sleeve, which prevented it from turning readily, and thus delayed or hindered the automatic discharge and readjustment of the machine. As soon as the irregularity was discovered and its causes located, the entire machine was cleansed and again put to practical work with the same excellent results.

This machine, like every other now in use in our sugar houses, must be kept in first-class order in order to obtain the best results. I am informed by the patentee that the machine had been further improved, with the probability of entirely overcoming the present apparent defects. This machine is also arranged to take a fair sample of each discharge. This was tried, with very unsatisfactory results. The hole, through which the small sample was discharged, frequently became more or less closed, causing very unequal discharges.

On a large scale in a sugar house working fairly uniform canes, the difficulty we experienced would hardly have been appreciated. But in an experimental sugar house, where in one experiment the discharges consisted of both the regular juice and the washings of the battery, such an equal discharge must vitiate the accuracy of the aggregation of samples. This defect, it is believed, can and will be easily remedied.

This machine has great merit, and when perfected, as is believed it will be very soon, will constitute one of the most valuable additions to a modern sugar house, enabling one to exercise with comparative chemical ease a control over the juice and sirup.

CLARIFIERS.

The juice was next pumped to the clarifiers, and then heated with chemicals for clarification. Connected with this clarifier was a sulphur machine by which a clarifier could be sulphured to any desirable extent. Arrangements are being made by which the scums from the clarifier can be sent directly to the diffusion battery or through a Pusey & Jones filter press. The latter was the course adopted in our experimental work, since an unknown quantity of juice with each return to the battery entered the chemical problem which the daily experiment attempted to solve.

DOUBLE EFFECT.

The juice from the clarifier was concentrated to sirup in an upright double effect of 400 square feet of heating surface. This double effect has, by the ordinary methods of running it, occasioned great loss by entrainment overflow. It has been found that by lowering the juice in each effect the loss diminished, until it was practically *nil*, when the tubes were kept about half full. The following method of working proved so successful that it will hereafter be followed: In starting the effects, juice is drawn in until the tubes are about half covered; then steam is turned on, and the level of the juice kept at this constant level. Looking in through the lower glasses, two curves can be seen, the juices rising from the tubes and falling down the "*downtake*." The quantity evaporated was also largely increased.

STRIKE PAN.

The sirup thus made was sent to the strike pan of same size as one of the effects. Here it was cooked to

grain, with little or no mechanical loss during the season. The masse cuite was taken to a *mixer*, and from it taken to a

HEPWORTH'S CENTRIFUGAL,

where it was purged of its molasses. The latter was cooked to slimy, and put into cars, and stored in the hot room.

Besides the above complete outfit, a small miniature equipment, consisting of a clarifier, an open evaporator, a very small strike pan and a hand centrifugal, was frequently used for making preliminary experiments with various chemicals, etc.—*La. Planter.*

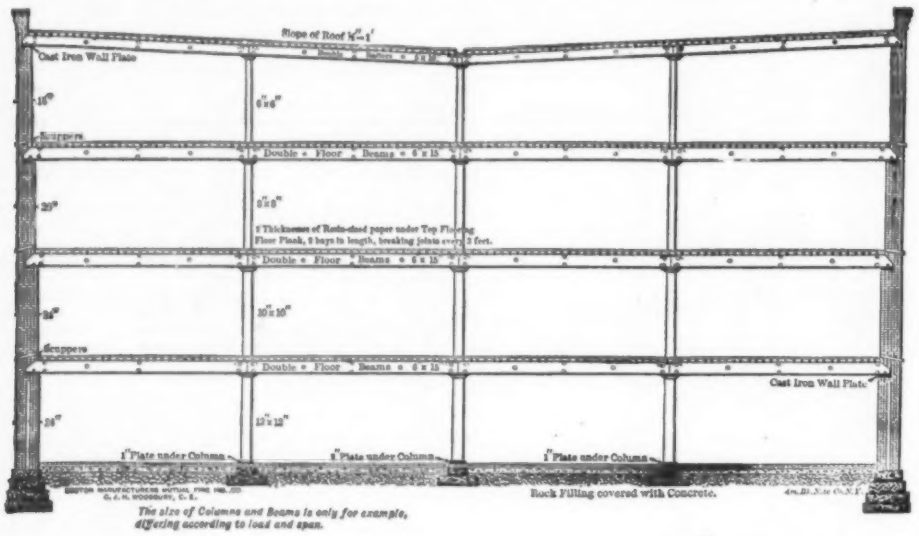
STANDARD STOREHOUSE CONSTRUCTION.

By C. J. H. Woodbury, Vice-President of the Boston Manufacturers Mutual Fire Insurance Company.

These illustrations represent salient points in design for a mill storehouse several stories in height and include many features found useful in practice for quantity of level land at disposal for this purpose, as being cheaper, more convenient, and, when separated into small divisions by fire-walls, the safest method of storehouse construction. Similar designs for one-story storehouses will be sent on application to persons connected with establishments insured in this company.

On reference to the drawing it will be seen that the floors are continuous, without openings, and of the standard slow-burning construction—a type which has not yet been burned through by any fire starting under such a floor. To reduce water damage, the floors are not level, but have a camber of two inches in the middle made by iron plates inserted under the columns in the basement. If it should become desirable to use the building for any purpose requiring level floors, they can be reduced to a level by removing these plates. Inclined iron tubes, with a light swinging cap on the outside, laid in the wall at the level of the floors, act as scuppers for the purpose of removing any water.

The beams are preferably of Southern pine bolted together in pairs, leaving about one inch space between

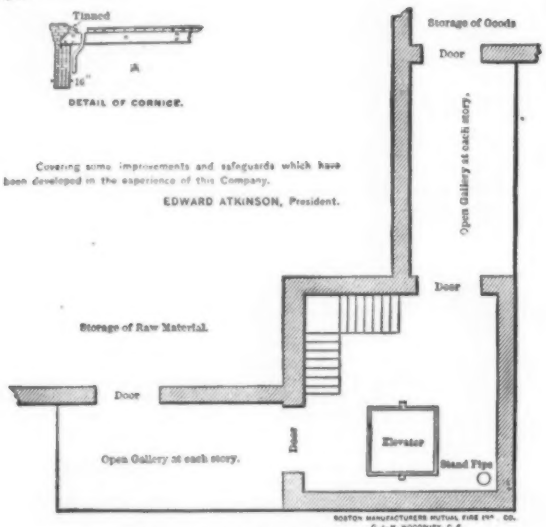


The size of Columns and Beams is only for example, differing according to load and span.

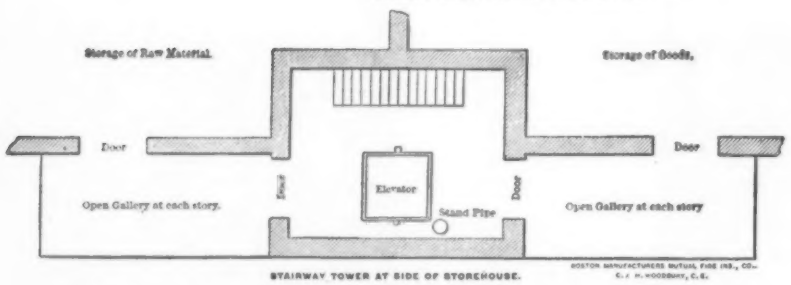
DETAIL OF CORNICE.

Covering some improvements and safeguards which have been developed in the experience of this Company.

EDWARD ATKINSON, President.



STAIRWAY TOWER AT CORNER OF STOREHOUSE.



STAIRWAY TOWER AT SIDE OF STOREHOUSE.

STANDARD STOREHOUSE CONSTRUCTION.

convenience in operation and also securing the greatest measure of resistance to fire.

This plan is not intended to take the place of the services of any mill engineer, but rather to assist in such work. This office holds itself in readiness to furnish to its members estimates of the strength of floors. It is important that the floor beams should be designed to sustain the greatest load ever to be placed on them, and the stories should be made low enough to prevent overloading, and also to prevent bales of material from being piled to too great a height, the preferable method being to place bales on end.

These floors, with beams of 20 feet span, laid 8 feet on centers, will sustain a load of 180 pounds per square foot, which is as much as would be required for raw material or finished goods of a textile or paper mill. The heavy drugs and dyestuffs would be placed on the ground floor.

For convenience, as well as to separate the different hazards of raw material and finished goods, the building may be divided into two sections by fire walls extending through the roof.

A storehouse one story in height is recommended in preference to this design whenever there is sufficient the beams. At the columns the beams are joined by dogs made of three-fourths inch round iron, driven in at the top, and they are anchored to the walls by cast iron wall plates, to which they are secured by means of a rib which fits into a groove crossing the underside of the beam. It is important that there should be a small space at each side and at the end of the beam, in order to allow free ventilation, for the purpose of preventing dry rot. The Goetz box anchor is a special form of wall plate which is especially adapted to such purposes.

The under floor is made of spruce plank, generally three inches thick, planed on the underside, and grooved at the edges, and fitted with hard wood splines. These plank are two bays in length, breaking joints at least every three feet. Over the plank are placed two thicknesses of resin-sized paper before the top floor of hard wood is laid. The floor is smoother if laid across the line of plank, and the traveling loads moved in or out of the storehouse are better distributed than when the top floor is laid parallel to the plank. The floor should not be secured to the walls, but a narrow strip, laid around the edges of the floor and fastened to the wall, covers any openings due to shrinkage.

The columns should be square Southern pine or oak, with iron cap, pintel, and base, preferably cast in one piece, and secured to the underside of the beam by six inch lag screws. The caps should be large enough to give the beams ample bearing surface.

If brick piers are placed in the basement, it is preferable, rather than to insert bond stones in the piers, to use a plate of boiler iron the size of the pier, and containing a number of inch holes punched on both sides over a board, in order to produce as large burrs as possible, to securely hold the masonry.

It is generally preferable that the roof should slope toward the center one-half inch to the foot, and the gutter should slope toward the drain pipes one-twentieth inch to the foot; but if the roof slopes toward the walls, the detail of cornice, A, illustrates the arrangement of gutters.

Access to the various stories is obtained only by means of a tower outside the main building and extending above the roof, containing stairways, elevator, and water pipes. At each story of the tower, open galleries communicate to the rooms on that level. A doorway from the upper story of the tower affords a ready means of reaching the roof. It is often a matter of great convenience if the doorway at the first story of the tower is made large enough, and at the outside grade, so that a wagon can be backed directly to the elevator. It is unnecessary to provide these elevators with automatic hatches, as guard gates serve every purpose. For the elevators in such towers, either hydraulic system or electric motors frequently furnish a more convenient means of applying the power than steam.

The system of tram rails hung from above, in connection with the triplex blocks, as constructed by the Yale & Towne Manufacturing Co., is a great convenience in handling the contents of storehouses.

The walls extend above the roof, and the parapet should be laid in cement, because the moisture readily absorbed by brick would otherwise pass downward and render walls in the top story damp. In some instances a course of brick dipped in coal tar is laid above the roof level. The illustration, A, shows a method of protecting a low parapet wall by plank which is tinned. This form of parapet also tends to reduce the amount of snow lodging on the roof.

The window openings are small, and omitted on sides exposed to other fire risks; but if there is any contingency that the building will ever be used for other purposes, it is advisable to lay the walls with arches and panels, in which openings can be made suitable for windows of large size, necessary to furnish light for manufacturing purposes.

In addition to yard hydrants near the buildings, there should be a six-inch standpipe in the tower, with two 2½ inch hydrants and hose at each story, and at top story of the tower the standpipe branches to a Morse monitor nozzle on the roof, if there are any adjacent buildings which might be reached by streams from this position.

A set of plugs from the roof drain pipes will allow the roof to be covered with water in case the property is endangered by sparks from burning buildings.

Automatic fire alarms with thermostats form a valuable auxiliary to the fire apparatus in storehouses.

If the contents of the storehouse are of such a nature that automatic sprinklers are advisable, it is preferable to shut off the water during freezing weather, rather than to rely upon the devices known as dry pipe systems.

ELECTRIC HEATING.

By Mark W. Dewey.

Very little has been done up to the present time in heating by electricity, and yet enough has been accomplished to demonstrate its practicability and its superiority over all other modes of heating. The common belief is that heating by electricity would be too costly. It is generally conceded that in all other particulars it is superior to other modes of heating; and when electricity is generated a little cheaper than it is at present that objection will be removed. The only objection, therefore, is that it is not economical. This was exactly what was said about electric lighting when it was first proposed, but after it came into use it was found that it could be supplied as cheaply as gas or other illuminants, and to-day it is used in all parts of the world, and people cannot speak too highly of its merits.

One well known inventor, while he admits that electric heating is undoubtedly the most convenient and the ideal method of artificially warming our places of habitation, has said that it will not be economical until we can transform the heat in the coal directly into electricity without the intervention of boilers and engines. This inventor is wrong, and certainly could not have examined the subject fully. Even if we are compelled to employ the steam engine in the generation of electricity for heating, as in many cases at present, when we cannot get water power, heating by electricity is just as economical as heating by coal. We need not wait for the time, though it may be close at hand, when electricity will be generated directly from the heat of coal; if it is as economical to heat by electricity now, the immense advantage possessed by this mode of heating over other modes should and will soon give it the preference.

The same inventor said, although it is not understood why, as will be seen further on, that electric heating costs nine times as much as ordinary heating, so that to heat by electricity it would be necessary to burn nine pounds of coal to get the heating effect of one pound. This he explains by the fact that under the best conditions we realize in electricity about one-tenth of the energy of the coal consumed, and when we turn that ten per cent. of electricity into heat we simply get nothing more than ten per cent.; therefore, to get electric heat equivalent to the heat in one pound of coal it is necessary to burn ten pounds. This inventor seems to have lost sight of the fact that when employing a coal furnace or stove for heating we get only about 40 per cent. of the energy of the coal, and that then we must use a superior and expensive grade of coal costing from three to six times as much as the grade of coal that can be consumed at a large generating or central station. It is possible for us to get 60 per cent. of the total energy as useful heat

from a first class furnace if carefully and properly regulated; but stoves do most of the heating in towns, and they give but one-fourth, or 25 per cent., of the total energy in useful heat. Three-fourths of the heat passes up the chimney. Air rushes through the crevices of doors and windows in draughts which are injurious to health.

We can get 10 per cent. of the heat energy expended at the central station, and in using a stove we may get 25 per cent. Electric heat, therefore, would cost two and a half times more than heat derived from the consumption of coal in a good stove, if the same grade of coal is used in both cases; but as the central station can and does use coal costing one-fourth or one-third of what we must pay for coal to burn in a stove, electric heat can be obtained as cheap as the heat obtained by means of a coal stove.

It is evident from the above that electric heat is as economical as the heat ordinarily derived directly from coal, but when we consider the numerous advantages of electric heating it appears to be more economical still. Take, for instance, a house heated by electricity in a town. Let the current come from the central station and heat coils of iron wire. These coils are very cheap, may be placed in any part of the house and arranged in almost any conceivable and desirable way to produce the best results for heating or cooking purposes. These coils can be placed just under or around the vessel holding the article to be cooked or baked. Less heat than usual would be required, for no soot would collect upon the bottom of the containing vessel. The fire risk would be much less than at present, as the wire never need be hot enough to cause fires or can be easily and completely protected. The heat supply can be turned on or off instantly; thus there will be no loss of fuel when the need of heat has ceased. This applies with great force to summer use. In heating, cooking or baking, the temperature can be kept uniform or controlled as desired. In cooking or baking, many things are spoiled and wasted because the heat cannot be regulated as desired or appears to be different than it really is. Many regulators have been devised for the automatic regulation of coal heaters, but none of them accomplish their purpose fully, for the reason that a coal heater cannot be automatically regulated except in a small degree. We must visit the furnace or stove now and then, supply it with coal, rake down the ashes, carry them out, clean the soot out of the flues so that it will have draught, and many other things. None of these things would be necessary with an electric heater. It can be thermostatically regulated perfectly the year around, and when the weather is warm enough or whenever from any cause the temperature of a house is raised above the point beyond which artificial or electric heat is not required, it will shut itself off and there will be no waste whatever; when the temperature falls below the predetermined point the current will be automatically put on again, so that the temperature will be kept uniform and healthful. A meter can be placed in the circuit to the heater which will register perfectly the amount of current consumed in producing the heat used, which of course is all that must be paid for. Coal stoves or furnaces do not possess this great advantage, and are often in use and wasting energy when an electric heater would be consuming nothing, and, not being in use, are not worn out as quickly as a stove. A coal stove is often run continuously during the summer season when two or three hours per day would be sufficient. This is done for various reasons; sometimes to save time or the undesirable job of cleaning out the stove and building a new fire, which necessitates the handling of kindling wood, ashes and coal, which in turn produces more or less dust, smoke and gas; and sometimes the fire is kept not only for these reasons, but because the weather is liable to change or become rapidly cooler, and at a time when time cannot be conveniently spared; so we keep the fire going day after day, especially in the spring and the fall, although it is warm enough to dispense with it, because we expect the weather to grow cooler; and often it does, and then we feel repaid for the heat energy we have wasted because it has saved us from building a new fire. But very often the weather does not grow cooler for several days and sometimes not at all; then much heat energy is wasted. With electric heat this would not be so, for the simple turning of a handle or switch, more or less, if automatic regulation was not used, would be all that would be required to turn the heat off or on as desired. We would therefore not waste the heat half a day or an hour.

Without rising in the morning, a button touched at the bedside may be made to turn the heat on in any or all parts of the house. The nuisance of kindling, smoke, gas, ashes and soot will be abolished, and no stovepipes, chimneys, scuttles, shovels, ash sifters, kindling wood, coal, or coal bins will be needed. Taking into consideration the cost of the articles above named, the trouble and fire risk, I am positive that electricity will not only be found as cheap, but much cheaper than heat supplied directly from coal as usual.

When the dynamo at the central station can be driven by water power, as is done in very many places at present and will be done in the future at a great many more, or when the central station is at places, such as Scranton, where coal mines are situated, greater economy can be obtained. Water power can be supplied ten hours a day at $20, and steam at $50 annually per horse power. In this case steam costs two and a half times as much as water.

It will be apparent from the above that electric heating would cost two and a half times as much as heating by stoves, if the same grade of coal was used in both cases, and in using water power to generate electricity the heat will cost the same as when produced in stoves, even neglecting the cost of the many articles above named that would be dispensed with.

Platinum wire has heretofore been used almost entirely for electric heating, but iron is as good and will be used in the future. The conductivity of soft iron is nearly as low as soft platinum, the ratio at the temperature of melting ice being as 20·73 to 18·03, and the cost nearly as 1 to 5,000.

Electric heating apparatus is much cheaper than other heating apparatus, as wires may be used in the place of pipes for conductors for the heat or the heating medium. No heat need be wasted, as each room can have its heater, and though small, will consume no more energy accordingly than a large heater.

Another thing to be noticed is that the electric current for heating may be the same as for lighting. The electric lighting station can produce it; the same wires that conduct the current for your lamps, whether arc or incandescent, may conduct the current also for the heaters: in fact, all that is necessary is that sufficient current be furnished a consumer to supply both his lamps and heaters. One of the greatest advantages possessed by electricity over the ordinary stove for heating, from a commercial standpoint, lies in the fact that the same current that is utilized for heating can also be used for lighting and power, and the current generated for all those purposes may be transmitted to the various points of consumption over the same circuit. Instead of numerous small heat generators, such as furnaces and stoves, a single large generating station, equipped with modern appliances for the economical production of electrical energy, such as improved boilers, furnaces, triple or quadruple expansion compound engines constantly working at full capacity, and storage batteries to store the electricity when the consumption is low, would be sufficient to supply a district with all the heat that may be required, without mentioning light and power, at a cost to the consumer that will compare favorably with what he is now called upon to pay for the fuel, attendance, etc., required by the present crude and wasteful methods of heating employed by him. The large increase in the size and earning capacity of these stations, due to the vastness of the field to be occupied by electric heating, will also greatly reduce the cost of current.

With the encouraging progress that has been made in the direction of providing more efficient and satisfactory methods of utilizing the current so as to obtain the greatest amount of heat therefrom, the problem of successful heating by electricity is practically solved, and there is every reason to believe that the time is short before electric heating will be generally adopted.

It may be said further that it has been proved beyond a doubt that electric cars can be heated as economically by electricity as by other means, and if electric cars, why not others, and also houses of all kinds where the electric current is used for lighting or other purposes?

One form of apparatus devised by the writer to render electric heating effective and economical is a floor or floor mat that can be electrically heated. This form of heater is capable of distributing the heat throughout the room or car in which it is placed more uniformly and exposes a large radiating surface to the atmosphere in all parts of the room or car. Floor mats are commonly used in street cars to prevent wear upon the floors and to keep persons from slipping. Mats the same or similar to those already in use are employed for the heater, the only essential requirements being that the mats be provided with heat-radiating conductors and connected to suitable supply conductors.

These mats are perfectly safe and effective. A very low tension current is employed to heat the mats and this current is passed through them. They can be and are arranged in some cases so that it is impossible to touch the conductor of the mats, but even if the conductor in the mat is not protected or shielded, it is utterly impossible to receive a shock by contact in any manner with the mat. In some cases flexible steel coiled spring mats will be employed for the purpose, as they offer the required electrical resistance, expose a very great radiating surface, and are easily removed for cleaning purposes.

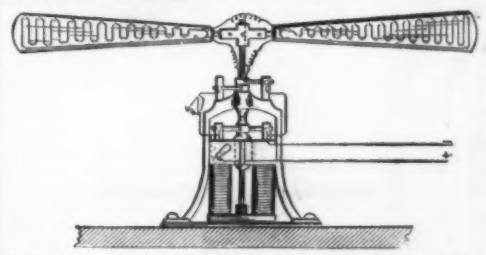


FIG. 2.—ELECTRIC HEATING APPARATUS.

By the employment of a mat heater the disadvantages common to the usual modes of artificial heating are removed, these disadvantages being due to the fact that the heat is concentrated in a particular locality, and therefore is not equally distributed as it should be, since the space in the vicinity of the old heater must be heated to an undesirable degree in order that remote localities may be raised to a comfortable temperature.

The large exposed radiating surface area of the mat heater will enable it to develop and radiate a great amount of heat without becoming very hot; that is, not hot enough to burn wood, leather or rubber in contact with it. It will be unnecessary to raise the heat in the mat above 100 degrees Fahrenheit on the coldest day in the winter to produce a comfortable temperature. This is not only because of the extended radiating surface of the heater, but on account of its position upon the floor. The heater does not take up valuable room, and in storage battery cars allows the entire space under the seats to be used for the batteries. These mat heaters are especially adapted for heating rooms and halls in houses. They may be made entirely of nickel or of bronze and formed into a grating of some beautiful design, which can rest upon tiling or marble and have its upper surface level with the floor. In order to prevent undue heating of the mats or to keep their temperature below the igniting point of wood, leather, etc., an automatic heat regulator is provided in the shape of a thermostatic cut-off or current controller, arranged so that it may be adjusted for any desired degree of temperature, and to cut out the mat when the temperature rises slightly above that predetermined.

In the accompanying illustrations, Fig. 1 represents a top view of two floor mats coupled together and connected with a suitable source of electricity to heat the mats, and a thermostatic current controller in the cir cuit to regulate the heat. Two different styles of mats are shown in this figure. The conductors leading from the source of electricity to the mats are of large cross-section and better conductivity than the mats, consequently the heat produced by the current is located in the mats. Both of these mats are formed of conducting and non-conducting material, as iron and wood, the conducting material forming the heat-radiating electric conductor and the non-conducting material forming the shield or protecting part. The conductor in the mat on the left of the figure is formed of zigzagged strips of iron or other metal placed between slats of hard wood thicker than the width of the strips, thus forming a shield for the strips or preventing contact with them. The strips of metal are connected by rivets extending through the slats. On account of the form of construction of this mat it is rigid and stiff, but the mat shown on the right of the figure is flexible, as coiled springs extend lengthwise through the slats and form the radiating conductors. The mats are provided with suitable terminals, to which the terminals of the circuit are connected. They can be quickly and easily connected to and disconnected from the circuit when desired by means of specially designed clamps.

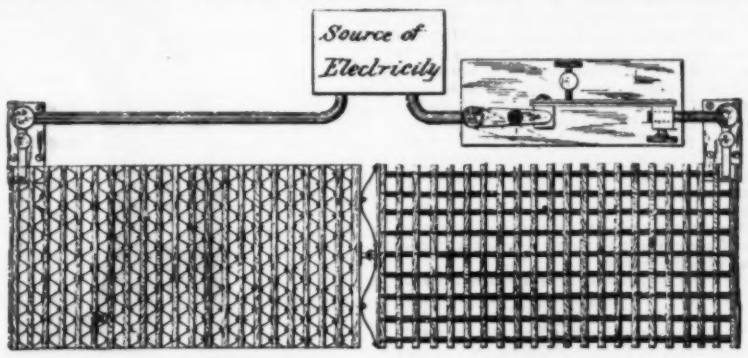


FIG. 1.—FLOOR MAT ARRANGED FOR ELECTRIC HEATING.

Fig. 2 represents a combined fan, or means to keep the air in motion, and an electric heater. When the air surrounding a heating conductor is kept in rapid motion, the conductor is able to produce more heat in a given time, and a heat-conducting medium, as asbestos or fire-clay, surrounding the conductor is unnecessary and may be dispensed with. With this heater all parts of the room are heated uniformly. It also ventilates the room and maintains a healthy atmosphere.

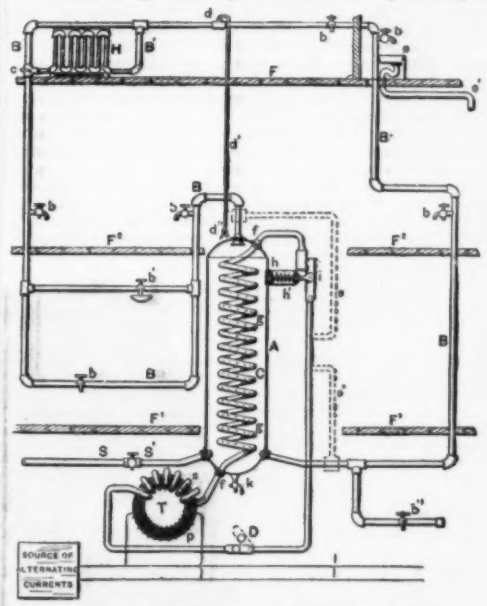


FIG. 3.—SYSTEM OF ELECTRICALLY SUPPLYING HOT WATER.

In warm weather the heater may be cut off and the fan used for ventilating purposes only. Many forms of apparatus may be devised having this principle; for instance, the heating conductor need not be mounted upon the fan, but on the stationary support in proximity to the fan, or the heating conductors may be arranged in a suitable manner in a pipe or flue, with a fan at one end to cause a current of air to pass through it.

Fig. 3 represents a system for electrically supplying

hot water for domestic or heating purposes, or both. With this apparatus the water is supplied to the boiler, A, by the pipe, S. The water is supplied from and to the boiler through the house by the circulating pipe, B. H is a hot water radiator connected with the pipe for giving out heat. By means of the cock, *c*, the water may be shunted around the radiator when heat is not desired. Many radiators may be connected with the pipe either in series or otherwise. When the system is used largely for heating purposes, although it is possible, it is not thought to be advisable to use the water for domestic purposes, as the temperature of the water becomes lower and the radiators may not give out the amount of heat desired. The water is drawn from the pipe at the faucets, *b*. The water is preferably heated in the boiler by means of a perforated coiled pipe located within the same and connected with the terminals of a suitable source of electricity, which is shown in the figure as generated by an inductional transformer, T. The current is automatically regulated by the pressure of the water in the boiler through the current controller, *t*. Although not shown, this controller is made adjustable, so that the water may be heated to any degree of temperature desired. When the water becomes too hot or rises above the temperature desired, the controller is moved to break the circuit, and when the water becomes cool again, the decrease of pressure in the boiler allows the controller to close the circuit. In some cases the heating current is also passed through the distributing pipe, B, which then becomes a heating conductor also. If preferred, the water may be heated by the passage of the current through the distributing pipe alone. In the latter case the boiler may be dispensed with. The heating of the distributing pipe may be done, however, for the purpose of assisting the boiler heater in maintaining a constant temperature.

Many forms of electric heaters or radiators may be employed for heating purposes that are directly heated by the electric current without using water. Such radiators may be made both efficient and light, and much more attractive than steam or hot water radiators and will not produce noise or give out unhealthy gases.

Electric heaters may be used to heat air which may be distributed to or circulated through rooms in houses by pipes and registers similar to those used with our coal furnaces, which are so hard to feed, clean and regulate.

Cooking stoves may be electrically heated and automatically regulated. Such stoves may be constructed so that the oven alone may be heated or any other part of the stove without heating the entire stove. The oven may contain an incandescent lamp and be provided with windows to enable the cook to see the contents without opening the door and allowing the heat to escape and the contents to be spoiled.

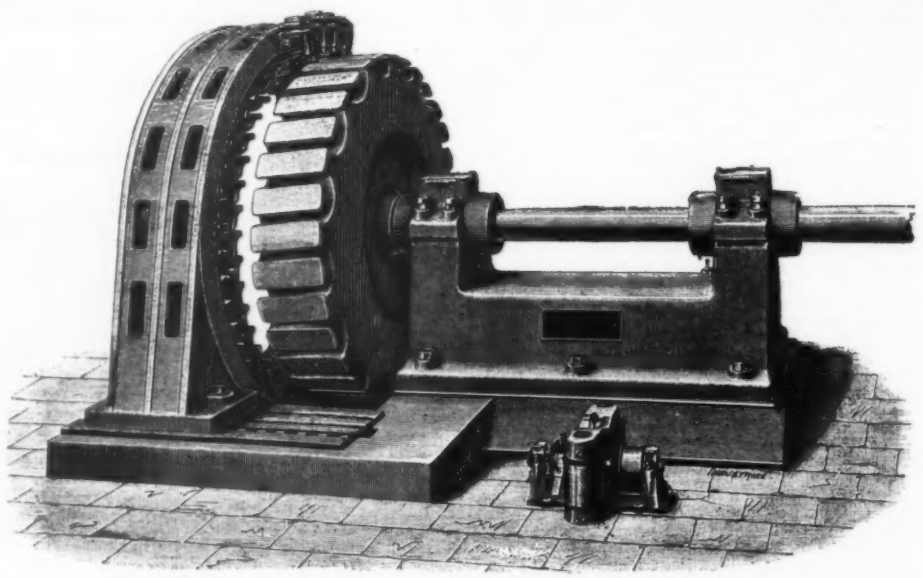
Those who admire the bright fire in a grate can enjoy it without the consumption of coal, wood, or other fuel by placing the incandescent lamps or an arc lamp beneath a body of glass, formed and covered, if need be, to represent a bed of coals or pieces of log wood, placed in the fireplace. The back and sides of the fireplace may be formed of mirrors if desired to magnify the effect, and if the heat is also desired, a small flat electric heater may be placed beneath, back of the ash guard.—*Electrical World.*

THE FRANKFORT ELECTRICAL EXHIBITION.

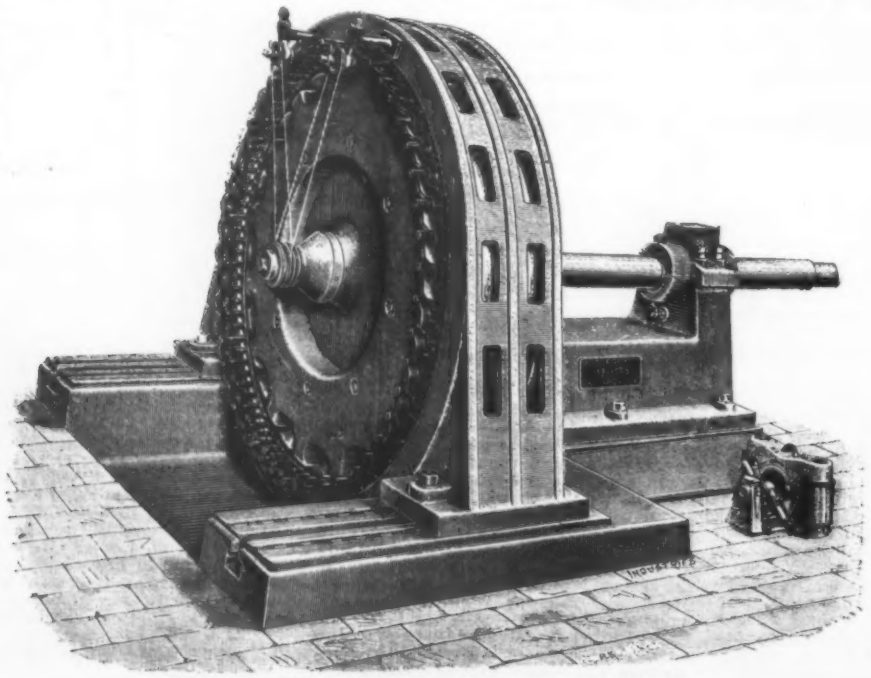
OUR illustrations show a triple current generator used for the transmission of 300 horse power from Lauffen to Frankfort. Distance 108 miles. It has been designed by Mr. C. E. L. Brown, and built by the Oerlikon Works. The field magnet rotates, and has thirty-two poles, which are excited by a single coil of wire. This admits of a very simple field magnet, and saves copper and loss of power in excitation. The armature is stationary, and has ninety-six conductors. These are embedded in the iron of the armature, a method that has been employed at Oerlikon for years with great success. The embedding of the armature conductors allows the air space to be reduced to a mere mechanical clearance, so that smaller field excitation can be employed. It also admits of the use of large solid bars without excessive Foucault currents. At no load the Foucault currents are obviously inappreciable. At full load, with solid conductors, there is an action somewhat analogous to the "Thomson effect" in transformers with one layer of thick wire in the cylinder. The stationary armature has several advantages. If it revolved there would have to be collectors for three circuits, each of 1,400 amperes. Instead of that, a few hundred watts are all that have to be carried to the rotating part of the machine.

The armature is wound for three currents differing a third of a period in phase. Each circuit has a pressure of 50 volts, a transformer being used to produce the pressure necessary for transmission to long distances. The armature conductors are a little over 1½ in. diameter. The armature disks are mounted on a cast iron ring resting on the bed-plate, so that the whole armature can be moved along clear of the rotating field magnets for inspection or repair, if such a thing should ever be necessary. The field current is not led in by brushes in the usual way, but is brought to two grooved rings by means of two metal bands. The field magnets carry 750 lb. of copper, and demand only about 150 watts, which are supplied by a small direct current machine. The stray power is given as 1·6 to 1·7 per cent, and the loss in the armature by resistance is 3,500 watts at full load. The commercial efficiency is thus 96 per cent., a remarkably good result for a machine run at such a low speed as this—viz., 150 revolutions per minute.

The Maschinenfabrik Oerlikon have made several large machines of this type, and they have been used both as generators and motors. When used as motors, we believe they are generally started by separately exciting both the generator and motor, and starting both from rest together in the way already described. —*Industries.*



TRIPLE CURRENT GENERATOR WITH FIELD MAGNET WITHDRAWN.



THE OERLIKON TRIPLE CURRENT GENERATOR.

THE KOUSMINE DIFFUSION BATTERY.

THE diffusion battery of M. Kousmine has been much used in Russia. By making use of the phenomenon of diffusion, M. Kousmine has succeeded in overcoming the increase in internal resistance of the bichromate of potash battery due to the formation of crystals on the positive electrode. The positive carbon electrode consists of four strips attached to the lid of the battery. The negative zinc electrode consists of a circular grating resting on the bottom of the battery. By means of a funnel a 15 deg. Baume solution of sulphuric acid is introduced until it just reaches the lower end of the carbon strips. A 6 to 7 per cent. solution of bichromate of potash is next introduced. The two liquids do not mix on account of the great difference in their densities. When the battery is short-circuited it is easy to see that chemical action only takes place close to the lower end of the carbon strips, which are gradually surrounded by a violet ring two or three millimeters deep. Above this region the bichromate solution retains its original color. The bichromate solution being very weak, the chromic crystals dissolve as soon as they are formed, and the positive electrode is not covered by a deposit as in other batteries. The solution of these crystals, having a greater density than the surrounding liquid, falls to the bottom. The sulphate of zinc also falls to the bottom of the cell, causing more sulphuric acid to rise. A cell having the following dimensions has been tested by a committee of experts: Height, 20 centimeters; diameter, 15 centimeters; surface of zinc, 178 square centimeters; bichromate solution, 6 per cent.; sulphuric acid, 15 deg. Baume. The committee reported that after having been circuited for 8½ hours on an external resistance of 0·32 ohm, and then left on an open circuit for 10½ hours, the cell continued to work for 4½ hours, when the circuit was again closed, and that it gave during 13 hours 36 ampere-hours for an expenditure of 48 grammes of zinc.

MOTHS.

THE moth works in the dark, too. But there are three of him—*Tinea pellionella*, Linn., *T. tapetzella*, Linn., and *Tineola biselliella*, Hummel. The insects of the first and commonest species, says a writer in the *Upholsterer*, are light brown, and distinguished by the spots. They begin to appear late in April, and may occasionally be seen flitting about as late as August. They pair off, and the female then searches for suitable places for the deposition of her eggs, working her way into dark corners, crevices of the walls, cracks in the floor, or deep in the folds of garments, apparently choosing by instinct the least conspicuous places. The moth lays from 18 to 149 eggs at a time. From these eggs hatch, in a period of from three to seven days, the white soft larvæ, or worms, all of which begin immediately to make a case for themselves from the fragments of the cloth upon which they feed. The case is in the shape of a hollow roll, a thirty-second to an eighth of an inch long. As the worms grow, they enlarge this case by adding material which they get by feeding.

The worm reaches its full growth in thirty-six days, and then crawling into some yet more protected spot remains torpid during the winter within its case, which by this time is thickened and fastened at either end, and is the full sized cocoon. The transformation of moth takes place within the case during the following spring. Such is the life round of the species. The worm feeds on woolen fabrics, furs—ah! every housewife knows all that it attacks too well.

Remedies for moths are varied and peculiar, and many a rich harvest has been reaped through the ignorance of people regarding the moth and its habits. Folks have bundled up their woolens and packed them away in their wardrobes and drawers full of tarboline, or carboline, or cedarline, or camphorline, and actually believed that they would be safe until the autumn. They have wrapped up hundreds of moth eggs, which eventually hatch the grubs. These odors will never kill a moth or destroy its life germs. True a moth will not voluntarily seek a nesting place where the odor exists, but if boxed up with an odor it cannot escape from, it simply proceeds to lay its eggs in the atmosphere, which becomes a second nature to the grub when hatched.

Anything saturated with arsenic, or creosote, or even salt, or impregnated with sulphur, the moth or worm will not touch; but these articles are obviously objectionable. The point which we would enforce is that the housewife should look out for the worm. It is difficult to kill the eggs by reason of their almost imperceptible diminutiveness, and difficult also to eradicate this moth by reason of its secretive habits. A benzine spray is sure death, but there are many objections to its use and danger from its inflammable character; still, if the ordinary ball atomizer is filled with benzine, and the vapor thrown into crevices against moth or eggs, it will destroy them, but no light should be brought into a room thus treated, until after it has been thoroughly aired and the odor dissipated.

Camphor, tobacco, naphthalene, and other strong

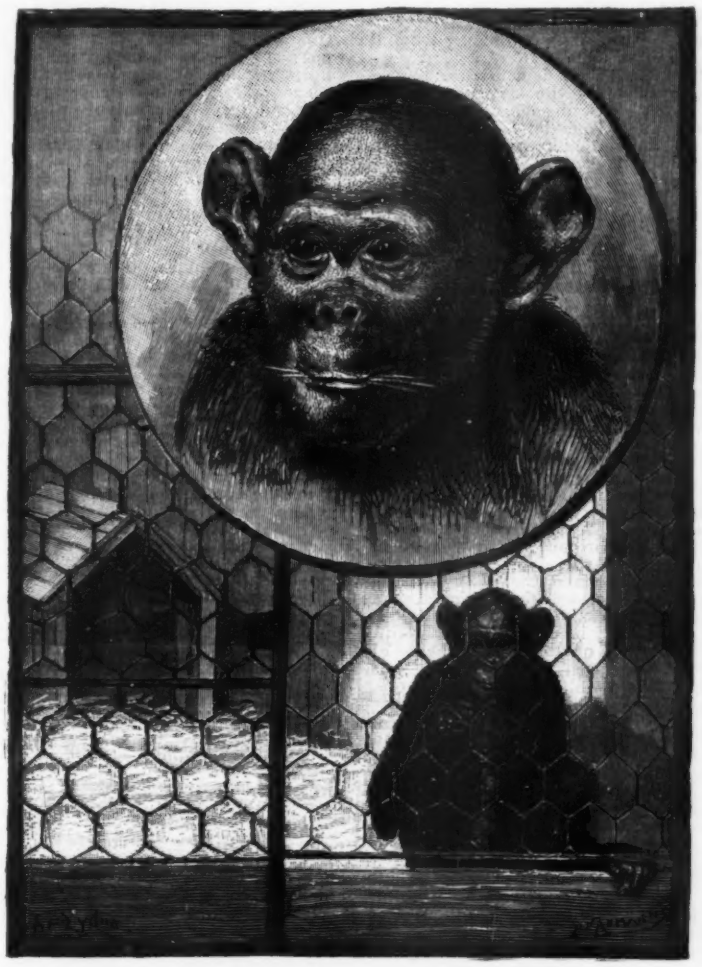
odorants are only partially repellent to the flying moth, and have no effect at all upon the egg or the worm. The benzine spray is the least objectionable destroying agent that we know of. It may be used very safely upon carpeting, but the utmost care should be exercised in using it on fabrics of a delicate character.

One should not confuse the moth with the carpet beetle. Frequently housekeepers discover their carpets eaten, and they attribute it to moths. The perfect beetle is three-sixteenths of an inch long, and when disturbed it draws in its legs and feigns death. It is white and black, scarlet being confined to a strip down the middle of the back. It begins to appear in the autumn, and soon the species pair off and the female deposits her eggs upon the carpet itself, and not in the cracks and crevices as generally supposed. During the daytime these beetles frequently fly to the windows and may be caught there, but they seldom leave the house until their eggs have been deposited. The treatment is similar to that with moths. A hand atomizer, charged with benzine, should be used to inject the liquid into all the floor cracks and under the baseboards, until every crevice has been reached. The carpets themselves, after thorough beating, should be lightly sprayed with the same substance.

THE CHIMPANZEE AT THE ZOOLOGICAL GARDENS.

By W. B. TEGETMEIER.

IT is doubtful whether any of the animals exhibited from time to time in our zoological collections are viewed with as much interest as those that constitute the nearest of our poor relations, the anthropoid or human-like apes, of which three distinct groups are known—the ourang-utans from Borneo, the gibbons from tropical Asia, and the gorillas and the chimpanzees from Western Africa. These are the most highly developed of all the animal creation, and approach the nearest to man. Unfortunately, they are all short-lived in our temperate climate, seldom living a sufficient time for their habits and instincts to be accurately studied. One remarkable exception, however, has been long familiar to the London public. Sally, the bald-headed chimpanzee, that was recently living in the Zoological Gardens, was a well known figure in London life. When Sally arrived at the gardens, in October, 1883, she was quite an infant, not having shed her first teeth; probably she might have been between two and three years old As soon as she arrived, it was seen that she differed from the ordinary chimpanzees, of which, since their commencement, more than thirty specimens have been exhibited in the gardens, all of which, unfortunately, were short-lived. The most important differences between Sally and her predecessors were that her face was almost black in color, that her head was destitute of hair, whereas in the ordinary chimpanzee the hair divides on the top of the head, falling to each side in tolerable abundance, and, again, her ears were very much larger. Hence Sally was regarded as the type of a new species, differing from the old one, and was called the bald chimpanzee, or, in scientific language, *Anthropopithecus calvus*. No sooner was this young creature located in the gardens than she showed a disposition to live upon animal food. If a small bird were let fly in her cage, she would adroitly catch it as it flew past her, bite off the head and eat it, skin and feathers included. This food seemed so natural to her that for many months Sally was supplied with a young pigeon, which she killed and ate every night. After a time she became more civilized, when cooked mutton and beef tea were substituted for this part of her dietary. The location of the Zoological Gardens, close to the Regent's Canal, is attended with one very serious inconvenience. The rats from the canal cannot be kept out. They are present in every part of the gardens to which they can get access, in spite of the numbers that have been constantly destroyed. To Sally, however, they were by no means an inconvenience. If a rat entered her cage at night it was invariably caught and killed by her. In these respects Sally differed very much from the ordinary chimpanzee, which Mr. Bartlett informs us he has never known to eat any kind of flesh, and he has had a large number of specimens under his care during the many years that he has been superintendent of the gardens. These were not the only distinctions that characterized Sally. She was undoubtedly far more intelligent than any of the larger apes that have ever before been kept in confinement. She was affectionate, hardly ever tired of romping and playing with her keeper, generally in a very good temper, although she occasionally behaved like a spoiled child. Sally was capable of being taught many things that showed considerable thought and a great amount of intelligence. She always obeyed her keeper, and was trained to such an extent that she could even count to a considerable number. The keeper had taught her to give the exact number of straws asked for, which she would select, pick up, arrange in a little bundle, and hand to him, whether she was told to select three, four, five, six, or seven; it was even said that she could go on to a greater number. She always recognized those who made her acquaintance, and paid marked attention and evinced an extraordinary amount of interest in colored people, whom she would receive with a loud cry, which sounded much like the syllables "bon, bun, bun."



SALLY, THE CHIMPANZEE AT THE ZOOLOGICAL GARDENS.

The chimpanzee may be regarded as the animal which approaches most nearly to man. Although smaller than the full grown gorilla, there is not the great disparity in the size or structure of the two sexes that there is in that animal. When the chimpanzee stands upright the arms reach only a short distance below the knees, being in this respect more human-like than any other ape. The face is furnished with distinct whiskers, eyebrows, and eyelashes. The forehead is more vaulted, and the brain, as might be expected from the intelligence of the animal, larger than in any other ape. The tusks are much smaller, and the whole of the teeth make a close approximation to those of the human species. The comparatively long life which Sally has passed in confinement is doubtless due to the conditions under which she was placed. Instead of being put in the crowded monkey house, she had, as most of our readers must be aware, a large room very much to herself, where the air was comparatively pure, and she was not irritated by the presence of other animals of the same kind. Her death was due to a complication of diseases. She did not die of that one which is generally, but erroneously, supposed to cause the death of the majority of monkeys—namely, consumption.

As, perhaps, the nearest approach to humanity that has ever been seen or studied in an adult state in this country, Sally excited very great and general interest. Her portrait was repeatedly published, photographs of her were constantly taken, experiments as to her intelligence were made by scientific investigators, and she was taught to perform actions, to obey orders, as we have said before, to count straws, by her keeper at the suggestion of those who endeavored to investigate her mental condition.

The death of Sally is a great loss to the gardens, and is one not likely to be supplied. No instances whatever are known of any of the larger apes attaining any age approaching to that which she had reached. The extraordinary human expression of her face was partly disguised by the enormous size of her ears. If, however, one of her portraits were taken, and a piece of paper or muslin, cut into the likeness of a mob cap, were placed around her face, her resemblance to a human being became at once wonderfully manifest, and we have seen many types of humanity that do not look as elevated in the scale of creation as the much lamented creature which has now passed away.—*Illustrated London News.*

SOME DIFFICULTIES IN THE LIFE OF AQUATIC INSECTS.*

By Professor L. C. MIALL.

WE understand insects to be animals of small size, furnished with a hard skin and six legs, breathing by branched air-tubes, and commonly provided in the adult condition with wings. The animals thus organized are pre-eminently a dominant group, as is shown by the vast number of the species and individuals, their universal distribution and their various habitat.

The insect type, like some fruitful inventions of man—paper or lithography, for instance—has proved so successful that it has been found profitable to adapt it to countless distinct purposes. I propose to consider one only of its infinitely varied adaptations, viz., its adaptation to aquatic life.

There are insects which run upon the earth, insects which fly in the air, and insects which swim in the water. The same might be said of three other classes of animals—the three highest—viz., mammals, birds and reptiles. But insects surpass all other classes of animals in the variety of their modes of existence. Owing to their small size and hard skin, they can burrow into the earth, into the wood of trees, or into the bodies of other animals. There are some insects which can live in the water, not as the mammal, bird or reptile does, coming up from time to time to breathe, but constantly immersed, like a fish. This is the more remarkable because insects are as a class air-breathers. Air-tubes or tracheæ, branching tubes, whose walls are stiffened by spiral threads, supply all the tissues of the body with air. That such an animal should be hatched in water and live almost the whole of its life immersed, a thing which actually happens to many insects, is a matter for surprise, and implies many modifications of structure, affecting all parts of the body.

The adaptation of insects to aquatic conditions seems to have been brought about at different times, and for a variety of distinct purposes. Many dipterous larvæ burrow in the earth. Some of these frequent the damp earth in the neighborhood of streams; others are found in earth so soaked with water that it might almost be called mud, though they breathe by occasionally taking in atmospheric air. In yet more specialized members of the same order we find that the larva inhabits the mud at the bottom of the stream, and depends for its respiration entirely upon oxygen dissolved in the water. The motive is usually that the larva may get access to the decaying vegetable matter found in slow streams, but some of these larvæ have carnivorous propensities.

Other insects merely dive into the water, coming up from time to time to breathe or skate upon the surface.

Nearly every order of insects contains aquatic forms, and the total number of such forms is very large. I believe that all are modifications of terrestrial types, and it is probable that members of different families have often betaken themselves to the water independently of one another.

The difficulties which aquatic insects have to encounter begin with the egg. It is in most cases convenient that the egg should be laid in water, though this is not indispensable, and the winged, air-breathing fly is, as a rule, ill-fitted for entering water. Some insect eggs hatch if they are merely scattered, like grains of sand, over the bottom of a stream, but others must be laid at the surface of the water, where they can gain a sufficient supply of oxygen. If the water is stagnant, it will suffice if the eggs are buoyant, like those which compose the egg-raft of the gnat, but this plan would hardly answer in running streams, which would carry light, floating eggs to great distances, or even sweep them out to sea. Moreover, floating eggs are exposed to the attacks of hungry creatures of various kinds, such as birds or predatory insect larvæ. These difficulties have been met in the cases of a number of insects by laying the eggs in chains or strings and mooring them at the surface of the water. The eggs are invested by a gelatinous envelope, which swells out the moment it reaches the water into an abundant, transparent mucilage. This mucilage answers more than one purpose. In the first place it makes the eggs so slippery that birds or insects cannot grasp them. It also spaces the eggs and enables each to get its fair share of air and sunlight. The gelatinous substance appears to possess some antiseptic property, which prevents water-moulds from attacking the eggs; for long after the eggs have hatched out, the transparent envelope remains unchanged. The eggs of the frog, which are laid in the stagnant water of ditches or ponds, float free at the surface, and do not require to be moored. The eggs of many snails are laid in the form of an adhesive band, which holds firmly to the stem or leaf of an aquatic plant. Some insects, too, lay their eggs in the form of an adhesive band. In other cases the egg-chain is moored to the bank by a slender cord.

The common two-winged fly, Chironomus, lays its eggs in transparent cylindrical ropes, which float on the surface of the water. During the summer months

* Evening discourse, delivered before the British Association, Cardiff, 1891, by L. C. Miall, Professor of Biology in the Yorkshire College.—*Nature.*

these egg-ropes, which are nearly an inch in length, may readily be found on the edges of a stone fountain in a garden or in a water trough by the side of the road. The eggs are arranged upon the outside of the rope in loops, which bend to right and left alternately, forming sinuous lines upon the surface. Each egg-rope is moored to the bank by a thread, which passes through the middle of the rope in a series of loops, and then returns in as many reversed and overlapping loops, so as to give the appearance of a lock-stitch. The thread is so tough that it can be drawn out straight with a needle without breaking. If the egg-rope is dipped into boiling water the threads become apparent, but in the natural state they are invisible, owing to their transparency. The mucilage is held together by the threads interwoven with the mucilage. The loops can be straightened without injury until the length of the rope is almost doubled. If stretched beyond this point, the threads become strained and do not recover their original shape when released. By means of these threads, firmly interwoven with the mucilage of the egg-rope, the whole mass of many hundreds of eggs is firmly moored, yet so moored that it floats without strain, and rises or falls with the stream. The eggs get all the sun and air which they require, and neither predatory insects, nor birds, nor water-moulds, nor rushing currents of water can injure them.

The eggs of the caddis-fly are laid in larger ropes, which, in some species, are very beautiful objects, owing to the grass-green color of the eggs. The egg-raft of the gnat, which has often been described, is well suited to flotation in stagnant water, and is freely exposed to the air, a point of unusual importance in the case of an insect which in all stages of growth seems to need the most efficient means of respiration, and whose eggs are usually laid in water of very doubtful purity. The lower or submerged end of each egg opens by a lid, and through this opening the larva at length escapes.

The eggs of water-haunting insects are in many ways particularly well suited for the study of development. The eggs of Chironomus, for instance, can always be procured during the summer months. They are so transparent as to admit of examination under high powers of the microscope as living objects, and as they require no sort of preparation, they may be replaced in the water after each examination to continue their development. This saves all trouble in determining the succession of the different stages—a point which usually presents difficulties to the embryologist. The whole development of the egg of Chironomus is completed in a few days (three to six, according to temperature), and it is therefore an easy matter to follow the process throughout with the help of three or four chains of eggs.

When the larvæ are hatched and escape into the water, new difficulties arise. Some have to seek their food at the surface of the water, and must yet be always immersed, others live upon food which is only to be found in rapid streams, and these run serious risk of being swept away by the rush of water. All need at least a moderate supply of oxygen, which has either to be drawn from the air at the surface or extracted from the water by special organs. The difficulty of breathing is, of course, greatly increased when the larva seeks its food at the bottom of foul streams, as is the case with certain Diptera. The larva of Chironomus, for example, feeds upon vegetable matter, often in a state of decay, which is obtained from the mud at the bottom of slow streams, and in this mud the larva makes burrows for itself, cementing together all sorts of materials by the secretion of its salivary glands, drawn out into fine silken threads. The burrows in which the larva lives furnish an important defense against fishes and other enemies, but they still further increase the difficulty of procuring a supply of air. Hence the larva frequently quits its burrow, especially by night, and swims toward the surface. At these times it loops its body to and fro with a kind of lashing movement, and is thus enabled to advance and rise in the water. From the well-aerated water at the surface of the stream it procures a free supply of oxygen, which becomes dissolved in the abundant blood of the larva. Four delicate tubes filled with blood, which are carried upon the last segment of the body, are believed to be especially intended for the taking up of dissolved oxygen. The tracheal system is rudimentary and completely closed, and hence gaseous air cannot be taken into the body. The dissolved oxygen, procured with much exertion and some risk, must be stored up within the body of the larva, and used with the greatest economy. It is apparently for this reason that the larva of Chironomus contains a blood-red pigment, which is identical with the hæmoglobin of vertebrate animals. The hæmoglobin acts in the Chironomus larva as it does in our own bodies, as an oxygen carrier, readily taking up dissolved oxygen, and parting with it gradually to the tissues of the body.

It is instructive to notice that only such Chironomus larvæ as live at the bottom and burrow in the mud possess the red hæmoglobin. Those which live at or near the surface have colorless blood, and a more complete, though still closed, tracheal system. The larva of the carnivorous Tanypus, which is found in the same streams, but does not burrow, has a much more complete tracheal system, and only enough hæmoglobin to give a pale red tint to the body. The larva of the gnat again, which has a large and open tracheal system, and in all stages of growth inhales gaseous air, has no hæmoglobin at all. A list of the many animals of all kinds which contain hæmoglobin shows that for some reason or another each of them requires to use oxygen economically. Either the skin is thick and the respiratory surface limited, or they are inclosed in a shell, or they burrow in earth or mud. We might expect to find that hæmoglobin would always be developed in the blood of animals whose respiration is rendered difficult in any of these ways, but any such expectation would prove to be unfounded, and there are many animals whose mode of life renders it necessary that oxygen should be stored and economically used, which contain no hæmoglobin in their blood. Hence, while we have a tolerably satisfactory reason for the occurrence of hæmoglobin in a number of animals whose respiratory surface is limited, and whose surroundings make it a matter of difficulty to procure a sufficient supply of oxygen, we have to admit that many similar animals under the same conditions manage perfectly well without hæmoglobin. Such admission is not a logical refutation of the explanation. I might fairly put forth the baldness of mankind as at least the principal reason for wearing wigs, and this explanation would not be impaired by any number of cases of bald men who do not wear wigs. The fact is that the respiratory needs even of closely allied animals vary greatly, and further, there are more ways than one of acquiring and storing up oxygen in their bodies.

Either the storage capacity for oxygen of the Chironomus larva is considerable, or it must be used very carefully, for the animal can subsist long without a fresh supply. I took a flask of distilled water, boiled it for three-quarters of an hour, closed it tight with an india-rubber bung, and left it to cool. Then six larvæ were introduced, the small space above the water at the same time being filled up with carbonic acid. The bung was replaced, and the larvæ were watched from day to day. Four of the larvæ survived for forty-eight hours, and one till the fifth day. Two of them changed to pupæ. Nevertheless, the water was from the first exhausted of oxygen, or nearly so.

The Chironomus larva is provided with implements suited to its mode of life. The head, which is extremely small and hard, carries a pair of stout jaws, besides a most complicated array of hooks, some fixed, some movable. The use of these minute appendages cannot always be assigned, but some of them are apparently employed to guide the silky threads which issue from the salivary glands. The first segment behind the head carries a pair of stumpy legs, which are set with many hooks. These are mainly used in progression, and help the larva to hitch itself to and fro in its burrow. A similar but longer pair of hooked feet is found at the end of the body. This hinder pair serves to attach the animal to its burrow when it stretches forth in search of food.

Creeping aquatic larvæ, such as Ephydra, possess several pairs of legs in front of the last pair, but the burrowing species, such as caddis worms, agree with Chironomus, not only in their mode of life, but also in the reduction of the abdominal legs to a single pair, which are conspicuously hooked.

The larval head in this, as in many other aquatic insects, is far smaller and simpler than that of the fly. The larval head is little more than an implement for biting and spinning, by no means such a seat of intelligence as it is in higher animals. In Chironomus it contains no brain; the eyes are mere specks of pigment, and the antennæ are insignificant. But the head of the fly incloses the brain, and bears elaborate organs of special sense—many-faceted eyes, and in the male beautiful plumed antennæ. This difference in size and complexity probably explains the fact that the head of the fly is not developed within the larval head, but in the thorax. It is only at the time of pupation that it becomes everted, and its appendages assume the position which they are ultimately intended to occupy.

At length the Chironomus wriggles out of the larval skin, and is transformed into a pupa. It no longer requires to feed, and the mouth is completely closed. It is equally unable to burrow, and usually lies on the surface of the mud. Two tufts of silvery respiratory filaments project from the fore end of the body just behind the future head, and these wave to and fro in the water as the animal alternately flexes and extends its body. At the tail end are two flaps, fringed with stout bristles, which form a kind of fan. The pupa virtually consists of the body of the fly, inclosed within a transparent skin. The organs of the fly are already complete externally, and even in microscopic detail they very closely resemble those of the perfect animal. These parts are, however, as yet very imperfectly displayed. The wings and legs are folded up along the sides of the body, and are incapable of independent movement. For two or three days there is no outward change, except that the pupa, which originally had the blood-red color of the larva, gradually assumes a darker tint. The tracheal system, which was quite rudimentary in the larva, but is now greatly enlarged, becomes filled with air, secreted from the water by the help of the respiratory tufts, and the pupa floats at the surface. At last the skin of the back splits, the fly extricates its limbs and other appendages, pauses for a moment upon the floating pupa case, as if to dry its wings, and then flies away.

This fly is a common object on our window panes, and would be called a gnat by most people. It can be easily distinguished from a true gnat by its habit of raising the fore-legs from the ground when at rest. It is entirely harmless, and the mouth parts can neither pierce nor suck. Like many other Diptera, the flies of Chironomus associate in swarms, which are believed in this case to consist entirely of males. The male fly has plumed antennæ with dilated basal joints. In the female fly the antennæ are smaller and simpler, as well as more widely separated.

In brisk and lively streams another dipterous larva may often be found in great numbers. This is the larva of Simulium, known in the winged state as the sand-fly. The Simulium larva is much smaller than that of Chironomus, and its blood is not tinged with red. The head is provided with a pair of ciliary organs, fan-like in shape, consisting of many longish filaments, and borne upon a sort of stem. The fringed filaments are used to sweep the food into the mouth. The larva of Simulium subsists entirely upon microscopic plants and animals. Among these are great numbers of diatoms, and the stomach is usually found half full of the flinty valves of these microscopic plants. The Simulium larva seeks its food in rapid currents of water, and a brisk flow of well-aerated water has apparently become a necessity to it. If the larvæ are taken out of a stream and placed in a vessel of clear water, they soon become sluggish, and in warm weather do not survive very long. It matters little, however, to the larvæ whether the water in which they live is pure or impure; and streams which are contaminated with sewage often contain them in great abundance. There are no externally visible organs of respiration, but the skin is supplied by an abundant network of fine tracheal branches, which, no doubt, take up oxygen from the well-aerated water in which the animal lives. From this network at the surface branches pass to supply all the internal organs. The Simulium larva is found upon aquatic weeds, and the pair of hind feet, which in Chironomus were shaped so as to enable the larva to hold on to its burrow, here become altered, so as to furnish a new means of attachment. The two feet are completely united into one. The two clusters of hooks found in the Chironomus larva form now a circular coronet, and the center of the inclosed space becomes capable of being retracted by means of muscles which are inserted into it from within. The larva is thus enabled to adhere to the smooth surface of a leaf, holding on by its sucker, which is, no doubt, aided by the circle of sharp hooks. Efficient as this adhesive organ undoubtedly is, it must be liable to derangement by occasional accidents, as, for instance, if there should be a sudden rush of water of unusual violence, or if the larva should be obliged to quit its hold in order to avoid some dangerous enemy. In the case of such an accident it is not easy to see how it will ever recover its footing. Swept along in a rapid current, we might suppose that there would be but a slender probability of its ever finding itself favorably placed for the application of its sucker and hooks. But such emergencies have been carefully provided for. The salivary glands, or silk organs, which the Chironomus larva uses in weaving the wall of its burrow, furnish to the Simulium larva long mooring-threads, by means of which it is anchored to the leaf upon which it lives. Even if the larva is dislodged, it is not swept far by the stream, and can haul itself in along the mooring-thread in the same way that a spider or a geometer larva climbs up the thread by which, when alarmed, it descended to the ground.

When the time for pupation comes, special provision has to be made for the peculiar circumstances in which the whole of the aquatic life of the Simulium is passed. An inactive and exposed pupa, like that of Chironomus, may fare well enough on the soft muddy bottom of a slow stream, but such a pupa would be swept away in a moment by the currents in which Simulium is most at home. When the time of pupation draws near, the insect constructs for itself a kind of nest, not unlike in shape the nest of some swallows. This nest is glued fast to the surface of a water weed. The salivary glands, which furnished the mooring threads, supply the material of which the nest is composed. Sheltered within this smooth and tapering case, whose pointed tip is directed up stream, while the open mouth is turned down stream, the pupa rests securely during the time of its transformation.

When the pupa case is first formed, it is completely closed and egg shaped, but when the insect has cast the larval skin, one end of the case is knocked off, and the pupa now thrusts the fore part of its body into the current of water. The respiratory filaments, which project immediately behind the future head, just as in Chironomus, draw a sufficient supply of air from the continually changed water around. The rings of the abdomen are furnished with a number of projecting hooks, which are able to grasp such objects as fine threads. The interior of the cocoon is felted by a number of silken threads, and by means of these the pupa gets an additional grip of its case. If it is forcibly dislodged, a number of the silken threads are drawn out from the felted lining of the case. The fly emerges into the running water, and I do not know how it manages to do so without being entangled in the current of water, and swept down stream. The pupa skin splits open just as it does in Chironomus, but remains attached to the cocoon.

The larva of the gnat is perhaps more familiar to naturalists of all kinds than any other aquatic dipterous insect. The interesting description, and, above all, the admirable engravings, of Swammerdam, now more than two hundred years old, are familiar to every student of nature.

The larva, when at rest, floats at the surface of stagnant water. Its head, which is provided with vibratile organs suitable for sweeping minute particles into the mouth, is directed downward, and, when examined by a lens in a good light, appears to be bordered below by a gleaming band. There are no thoracic limbs. The hind limbs, which were long and hooked in the burrowing Chironomus larva, and reduced to a hook-bearing sucker in Simulium, now disappear altogether. A new and peculiar organ is developed from the eighth segment of the abdomen. This is a cylindrical respiratory siphon, traversed by two large air tubes, which are continued along the entire length of the body, and supply every part with air. The larva ordinarily rests in such a position that the tip of the respiratory siphon is flush with the surface of the water, and, thus suspended, it feeds incessantly, breathing uninterruptedly at the same time. When disturbed, it leaves the surface by the sculling action of its broad tail. Once below the surface, it sinks slowly to the bottom by gravity alone, which shows that the body is denser than the water. We have, therefore, to explain how it is enabled to float at the surface when at rest. The larva does not willingly remain below for any length of time. It rises by a jerking movement, striking rapid blows with its tail, and advancing tail foremost. When it reaches the top, it hangs as before, head downward, and resumes its feeding operations.

In order to explain how the larva hangs from the surface against gravity, I must trouble you with some account of the properties of the surface film of water. You will readily believe that I have nothing new to communicate on this subject, and I venture to show you a few very simple experiments, merely because they are essential to the comprehension of what takes place in the gnat.*

In any vessel of pure water, the particles at the surface, though not differing in composition from those beneath, are nevertheless in a peculiar state. I will not travel so far from the region of natural history as to offer any theoretical explanation of this state, but will merely show you experimentally that there is a surface-film which resists the passage of a solid body from beneath. [Mensbrugghe's float shown.] You see (1) that the float is sufficiently buoyant to rise well out of the water; (2) that, when forcibly submerged, it rises with ease through the water as far as the surface-film; (3) that it is detained by the surface-film, and cannot penetrate it. The wire pulls at the surface-film and distorts it, but is unable to free itself. In the

* A number of other experiments, illustrating the properties of the surface film of water, are described by Prof. Boys in his delightful book on "Soap Bubbles."

same way the surface film resists the passage of a solid body which attempts to penetrate it from above. This will be readily seen if we throw a loop of aluminum wire upon the surface of water. [Experiment shown.] The loop of wire floats about like a stick of wood. Aluminum is, of course, much lighter than iron, but the floating of this little bar does not mean that it has a lower density than that of water. If the bar is once wetted, it sinks to the bottom and remains there. Even a needle may, with a little care, be made to float upon the surface of perfectly pure water. Still more readily can a piece of metallic gauze be made to float on water. [Experiment shown.] Air can pass through the meshes with perfect ease; water also can pass through the meshes with no visible obstruction. But the surface-film, bounding the air and water, is entirely unable to traverse even meshes of appreciable size. These simple experimental results will enable us to appreciate certain facts of structure which would otherwise be hard to understand, and which have been wrongly explained by naturalists of the greatest eminence, to whom the physical discoveries of this century were unknown.

We may now try to answer three questions about the larva of the gnat, viz.:

(1) How is it able to break the surface-film when it swims upward?

(2) How is it able to remain at the surface without muscular effort, though denser than water?

(3) How is it able to leave the surface quickly and easily when alarmed?

The tip of the respiratory siphon is provided with three flaps, two large and similar to one another, the third smaller and differently shaped. These flaps can be opened or closed by attached muscles. When open, they form a minute basin, which, though not completely closed, does not allow the surface-film of water to enter. When closed, the air within the siphon is unable to escape. At the time when the larva rises to the surface, the pointed tips of the flaps first meet the surface-film, and adhere to it. The attached muscles then separate the flaps, and in a moment the basin is expanded and filled with air. The surface-film is now pulling at the edges of the basin, and the pull is more than sufficient to counterbalance the greater density of the body of the larva, which accordingly hangs from the surface without effort. When the larva is alarmed, and wishes to descend, the valves close, their tips are brought to a point, and the resisting pull of the surface-film is reduced to an unimportant amount. [Living larvæ shown by the lantern.]

Swammerdam found it necessary, in explaining the flotation of the larva of the gnat, to suppose that the extremity of its siphon was supplied with an oily secretion which repelled the water. No oil gland can be discovered here or elsewhere in the body of the larva, and indeed no oil gland is necessary. The peculiar properties of the surface-film explain all the phenomena. The surface-film is unable to penetrate the fine spaces between the flaps for precisely the same reason that it is unable to pass through the meshes in a piece of gauze.

After three or four moults the larva is ready for pupation. By this time the organs of the future fly are almost completely formed, and the pupa assumes a strange shape, very unlike that of the larva.

At the head end is a great rounded mass, which incloses the wings and legs of the fly, besides the compound eyes, the mouth parts, and other organs of the head. At the tail end is a pair of flaps, which form an efficient swimming fan. The body of the pupa, like that of the larva, is abundantly supplied with air tubes, and a communication with the outer air is still maintained, though in an entirely different way. The air tubes no longer open toward the tail, as in the larva, but toward the head. Just behind the head of the future fly is a pair of trumpets, so placed that in a position of rest the margins of the trumpets come flush with the surface of the water. Floating in this position the pupa remains still, so long as it is undisturbed, but if attacked by any of the predatory animals which abound in fresh water, it is able to descend by the powerful swimming movements of its tail fin.

Not that the descent is without its difficulties. The pupa is not like the larva, denser than water, but buoyant. There are two respiratory tubes in the pupa, whereas there is only one in the larva, and to these two tubes the surface-film clings with a tenacity of which only experiment can give an adequate idea. Will you allow me to give you a little more borrowed physics?

If we take a solid body, capable of being wetted by water, and place it in water, the surface-film will adhere to the solid. If the solid is less dense than the water, it will float with part of its surface out of water. Under such circumstances the surface-film will be drawn upward around the solid, and will therefore pull the solid downward. But if the solid is denser than the water, the surface-film around the solid will be pulled downward, and will pull the solid upward. Suppose that a solid of the same density as water floats with part of its surface in contact with air, and that weights are gradually added to it. The result will be that the surface of the water around the upper edge of the solid will become more and more depressed. The sides of the depression will take a more vertical position, until at last the upward pull of the film becomes unable to withstand further increase of weight. If this point is passed, the solid will sink. Before this point is attained, we shall have the solid, though denser than water, kept at the surface by the pull of the surface-film.

This state of things may be illustrated by a model. [Float with glass tube attached to its upper surface.] You will readily see that the float has to be weighted appreciably in order to break the connection of the tube with the surface-film. Now the pupa of the gnat has a pair of tubes which are in like manner attached to the surface of the water. When it requires to descend, the pull of the surface-film would undoubtedly be considerable. Adding weight to the body is, of course, impossible, and a great exertion of muscular force would be wasteful of energy, even if it could be put forth. The gnat deals with its difficulty in a neater way than this, and saves its muscular power for other occasions. Let me show you a method of freeing the float from the surface, which was suggested by observation of what was seen in the pupa of the gnat. A thread wetted with water is drawn over the mouth of each tube. It cuts the connection with the surface, and the float, loaded so as to be denser than water, goes down at once. Meinert has described a pencil of hairs which appear to perform the same office for the pupa of the gnat. The hairs draw a film of water over the open mouth of each respiratory tube, and muscular contraction, used moderately and economically, does the rest. When the pupa again comes to the surface the tubes are overspread by a glistening film of water. This is partially withdrawn by a movement of the hairs, so that a chink appears by which air can be slowly renewed. When the insect is completely tranquil, the hairs appear to withdraw more completely, and the tube suddenly becomes free of all film. The act of opening or closing the film is so rapid—like the wink of an eye—that I cannot pretend to have observed more than the closed tube, the slightly open tube, and then the sudden change to a completely open condition. [Living pupæ shown by the lantern.]

Another dipterous larva described and admirably figured by Swammerdam is the larva of Stratiomys, a larva which, as the structure of the fly shows, belongs to an altogether different group from Chironomus, Simulium, or the gnat. Though only remotely connected with the gnat in the systems of zoologists, the Stratiomys larva has learned the same lesson, and is equally well fitted to take advantage of the peculiar properties of the surface-film. The tail end of the Stratiomys larva is provided with a beautiful coronet of branched filaments. When this coronet is extended, it forms a basin open to the air and impervious to water, by reason of the fineness of the meshes between the component filaments. Were the larva provided with a basin of the same proportions formed out of continuous membrane, it might float and breathe perfectly well, but the old difficulty would come back, viz., that of freeing itself neatly and quickly when some sudden emergency required the animal to leave the surface. As it is, the plumed filaments collapse and their points approach; the side branches are folded in, and the basin is in a moment reduced to a pear-shaped body, filled with a globule of air, and reaching the surface of the water only by its pointed extremity. Down goes the Stratiomys larva at the first hint of danger, swimming through the water with swaying and looping movements, somewhat like those of Chironomus. When the danger is past, it ceases to struggle, and floats again to the surface. The pointed tip of its tail fringe pierces the surface-film, the filaments separate once more, and the floating basin is restored.

The larva of Stratiomys is extremely elongate. The length of its body has evidently some relation to the mode of life of the larva, but none at all to that of the fly which is formed within it. The pupa is so much smaller than the larva as to occupy only the fore part of the space within the larval skin.* The interval becomes filled with air, and during the pupal stage the animal floats at the surface within the empty larval skin.

Stratiomys, both in its larval and pupal states, floats at the surface of the water. The larva can descend into the water when attacked, but the pupa is too buoyant, and too much encumbered by its outer case, to execute any such maneuver. Provision has accordingly to be made for the protection of the helpless pupa against its many enemies. It is probable that hungry insects and birds mistake the shapeless larval skin, floating passively at the surface, for a dead object. The considerable space between the outer envelope, or larval skin, and the body of the pupa may keep off others, for the first bite of a Dytiscus or dragon fly larva would be disappointing. Still further security is gained by the texture of the larval skin itself. The cuticle consists of two layers. The inner is comparatively soft and laminated, while the outer layer is impregnated with calcareous salts, and extremely hard. The needful flexibility is obtained by the subdivision of the hard outer layer. Seen from the surface, it is broken up into a multitude of hexagonal fields, each of which forms the base of a conical projection, reaching far into the softer layer beneath. The conical shape of these calcareous nails allows a certain amount of bending of the cuticle, while the whole exposed surface is protected by an armor, in which even the pointed mandibles of a Dytiscus larva can find no effective chink.

The larva and pupa of the dipterous fly, *Ptychoptera paludosa*, exhibit some interesting adaptations of the tracheal system to unusual conditions. The larva is found in muddy ditches, where it buries itself in the black ooze to a depth of an inch or two. Here, of course, it can procure no oxygen, either gaseous or dissolved. When it requires a fresh supply, it must reach the surface with part of its body, and to enable it to do so with the least possible exertion, the tail end of the body is made telescopic, like that of another and still more familiar dipterous larva, Eristalis. The last segments are drawn out very fine, and are capable of a very great amount of retraction or expansion. No visible opening for the admission of air has been discovered, nor do the hairs form a floating basin, as in the Stratiomys larva. The larva may be often seen lying just beneath the surface, which is broken by the tip of the tail. Whether air can be admitted here by some very minute orifice, or whether it is renewed by the exchange of gases through a thin membrane, I cannot as yet venture to say. In shallow water the larva may be occasionally found lying on or in the mud, and stretching out its long tail to the surface. In deeper water, it often floats at the surface.

Two tracheal trunks run along the whole length of the body, including the slender tail, where they are extremely convoluted and unbranched. Toward the middle of the body the tracheæ become greatly enlarged in the center of each segment, the intervening portions, from which many branches are given off, being comparatively narrow. Each tube, therefore, resembles a row of bladders connected by small necks. A cross section shows that the tubes are not cylindrical, but flattened, and that, while the lower surface is stiffened by the usual parallel thickenings, the upper surface is thrown into two deep, longitudinal furrows, so that it is readily inflated, becoming circular in section, and readily collapses again when the air is expelled. It seems likely that the buoyancy of the larva can be thus regulated, and a larger or smaller quantity of air taken in as desired.

The pupa has a pair of respiratory tubes, which are carried, not on the tail, but on the thorax, close behind the head. One of these tubes is very long, the other very short. The long tube is twice as long as the body, and tapers very gradually to its free tip. Here we find a curious radiate structure, rather like the teeth of a moss capsule, which seems adapted for opening and closing. There is, however, no orifice which the most careful scrutiny has succeeded in discovering. A delicate membrane extends between the teeth, and prevents any passage inward or outward of air in mass. The tube incloses a large trachea, the continuation of one of the main tracheal trunks. This is stiffened by a spiral coil, but at intervals we find the coil deficient, while the wall of the tube swells out into a thin bladder. However the tube is turned, a number of these bladders come to the surface. As the pupa lies on the surface of the mud, the filament floats on the top of the water, and the air is renewed without effort through the thin-walled bladders.

Why should the position of the respiratory organs be changed from the tail end in the larva to the head end in the pupa? Chironomus, the gnat, Corethra, and many other aquatic insects exhibit the same phenomenon. Evidently there must be some reason why it is more convenient for the larva to take in air by the tail, and for the pupa to take in air by the head. Let us consider the case of the larva first. Where it floats from the surface, or pushes some part of its body to the surface, it is plain that the tail must come to the top and bear the respiratory outlet, for the head bears the mouth and mouth organs, and must sweep to and fro in all directions, or even bury itself in the mud in quest of food.

To divide the work of breathing and feeding between the opposite ends of the body is of obvious advantage, for the breathing can be done best at the top of the water, and the feeding at the bottom, or at least beneath the surface. Such considerations seem to have fixed the respiratory organs at the tail of the larva. Why, then, need this arrangement be reversed when the insect enters the pupal stage? There is now no feeding to be done, and it surely does not signify how the head is carried. Why should not the pupa continue to breathe like the larva, by its tail, instead of developing a new apparatus at the opposite end of its body, as if for change's sake? Well, it does not appear that, so far as the pupa itself is concerned, any good reason can be given why the larval arrangement should not continue. But a time comes when the fly has to escape from the pupa case. The skin splits along the back of the thorax, and here the fly emerges, extricating its legs, wings, head, and abdomen from their close-fitting envelopes. The mouth parts must be drawn backward out of their larval sheaths, the legs upward, and the abdomen forward, so that there is only one possible place of escape, viz., by the back of the thorax, where all these lines of movement converge. If, then, the fly must escape by the back of the thorax, the back of the thorax must float uppermost during at least the latter part of the pupal stage. Otherwise the fly would emerge into the water instead of into the air. Granting that the back of the thorax must float uppermost in the pupal condition, it is clear that here the respiratory tubes must be set.

I need hardly speak of the many insects which run and skate on the surface of the water in consequence of the peculiar properties of the surface film. They are able to do so, first, by reason of their small size; secondly, because of the great spread of their legs; and thirdly, on account of the fine hairs with which their legs are provided. The adhesion of the surface film is measured by the length of the line of contact, and accordingly the multiplication of points of contact may indefinitely increase the support afforded by the surface of the water.

In the case of very small insects, it becomes possible, not only to run on the surface of the water, but even to leap upon it, as upon a table. This is particularly well seen in one of the smallest and simplest of all insects—the little black Podura, which abounds in sheets of still water. The minute and hairy body of the Podura is incapable of being wetted, and the insect frisks about on the silvery surface of a pond just as a house fly might do on the surface of quicksilver. This is all very well so long as the Podura is anxious only to amuse itself, or move from place to place, but it has to seek its food in the water, and, indeed, the attractiveness of a sheet of water to the Podura lies mainly in the decaying vegetation far below the surface. But if the insect is thus incapable of sinking below the surface, how does it ever get access to its submerged food? I have endeavored to arrive at the explanation of this difficulty by observation of Poduras in captivity. If you place a number of Poduras in a beaker half full of water, they are wholly unable to sink. They run about and leap upon the surface, as if trying to escape from their prison, but sink they cannot. I have chased them about with a small rod until they became excited and much alarmed, but they were wholly unable to descend.

Even when large quantities of alcohol were added to the water the dead bodies of the Podura are seen floating at the top, almost as dry as before. It is only when they are placed upon the surface of strong alcohol that the dead bodies become wetted, and after a considerable time are seen to sink. How, then, does the Podura ever descend to the depths where its food is found?

I found it an easy matter to make a ladder, by which the Podura could leave the upper air. A few plants of duck weed introduced into the beaker enabled them at pleasure to pull themselves forcibly through the surface film, and climb down the long root hanging into the water like a rope. Once below the surface, the Podura, though buoyant, is enabled, by muscular exertion, to swim downward to any depth.

Other aquatic insects, not quite so minute as the Podura, experience something of the same difficulty. A Gyrinus, or a small Hydrophilus, finds it no easy matter to quit the surface of the water, and is glad of a stem or root to descend by.

To leave our aquatic insects for a moment, we may

* So singular is the disproportion between the larva and the pupa that some naturalists have actually described the latter as a parasite (Westwood's "Mod. Classification of Insects," vol. ii., p. 532).

notice the habit of creeping on the underside of the surface film, which is so often practiced by leeches, snails, cyclas, etc. I find this is often described as creeping on the *air*, and some naturalists of the greatest eminence speak of fresh-water snails as creeping "on the stratum of air in contact with the surface of the water."* The body of the animal is, nevertheless, wholly immersed during this exercise, as may be shown by a simple experiment. If Lycopodium powder is sprinkled over the water, the light particles are not displaced by the animal as it travels beneath. The possibility of creeping in this manner depends, not upon any "repulsion between the water and the dry surface of the body," to quote an explanation which is often given, but upon the tenacity of the surface film, which serves as a kind of ceiling to the water chamber below. The body of the leech is distinctly of higher specific gravity than the water, and falls quickly to the bottom, if the animal loses its hold of the surface film. The pond snails, however, actually float at the surface, and if disturbed, or made to retract their foot, they merely turn over in the water.

What is the result of all the expedients which have enabled air-breathing insects to overcome the difficulties of living in water? They have been successful, we might almost say too successful, in gaining access to a new and ample store of food. Aquatic plants, minute animals, and dead organic matter of all kinds abound in our fresh waters. Accordingly the species of aquatic insects have multiplied exceedingly, and the number of individuals in a species is sometimes surprisingly high. The supply of food thus opened out is not only ample, but in many cases very easy to appropriate. Accordingly the head of the larva degenerates, becomes small and of simple structure, and may be in extreme cases reduced to a mere shell, not inclosing the brain, and devoid of eyes, antennæ, and jaws. The organs of locomotion also commonly afford some indications of degeneration.

Where the insect has to find a mate, and discover suitable sites for egg laying, the fly at least must possess some degree of intelligence, keen sense organs, and means of rapid locomotion. But some few aquatic insects, as well as some non-aquatic species, which have found out an unlimited store of food, manage to produce offspring from unfertilized eggs, and to have these eggs laid by wingless pupæ or hatched within the bodies of wingless larvæ.

The development of the winged fly, the whole business of mating, and even the development of the embryo within the egg, have thus, in particular insects, been abbreviated to the point of suppression. This is what I mean by saying that the pursuit of a new supply of food has in the case of certain aquatic insects proved even too successful. Abundant food, needing no exertion to discover or appropriate it, has led in a few instances to the almost complete atrophy of those higher organs and functions which alone make life interesting.

The degeneration of aquatic insects, however, very rarely reaches this extreme. In nearly all cases the pupa is succeeded by a fly, whose activity is in striking contrast to the sluggishness of the larva. They differ, to the eye at least, almost as much as air differs from water.

Of the friends to whom I am indebted for help, I must specially name my fellow worker, Mr. Arthur Hammond, who has communicated to me many results of his own observations, and has drawn most of the illustrations shown this evening. My colleague, Dr. Stroud, has very kindly arranged, and in some cases devised, the physical experiments which have been so helpful to us.

* Semper's, "Animal Life," Eng. trans., p. 205, and note 97.

CULTURE OF THE GRAPEVINE IN FRANCE.

At a time when a movement is assuming shape in favor of agriculture, the principal source of France's wealth, it seems to us proper to attract special attention to the interest presented by the culture of the vine and to the advantageous use to which capital may be put in the restoration of our vineyards.

Statistics show us that out of the three million or more acres occupied by the French vineyards before the advent of the phylloxera more than twenty-five hundred thousand have been devastated. It may be added that the phylloxera is continuing its work of destruction, and that the vines that have resisted the scourge up to the present are all threatened, if not already attacked. Yet the trouble is not without a remedy.

Certain favored regions whose wines are the jewels of French viticulture have been able (at great expense in most cases) to fight off the insect and to keep up their production; but most of the middling wines could not support so high yearly expenses. Submersion is possible only within limited areas, and is impossible in all cases upon declivities.

The use of sulphide of carbon and of the sulpho-carbonates is not always practicable in all the vineyards, especially in the extensive grounds that are so well adapted for a large production. The use of sulpho-carbonates, moreover, requires the use of quantities of water that in most cases are not to be found in proximity to the majority of vineyards.

But there is one means that has been confirmed by practice, and that is the use of certain American species whose roots resist the attacks of the insect, at least in certain kinds of ground. Among such stocks there are some that might be used as direct producers; but those that are known and have been experimented with up to the present generally give common wines, the best of which are certainly inferior in quality to the products of our old French vine stocks, of which the renown is universal. We say purposely those at present known, for we have good reason to believe that the patient and able researches of eminent hybridists, such as Millardet, Coudere, Gauzin, etc., will end in the discovery or rather the creation of those so-much-desired stocks which, with immunity from the phylloxera, shall join quality of fruit, flavor and abundance, and even resistance, if not complete, at least sufficient to cryptogamic diseases.

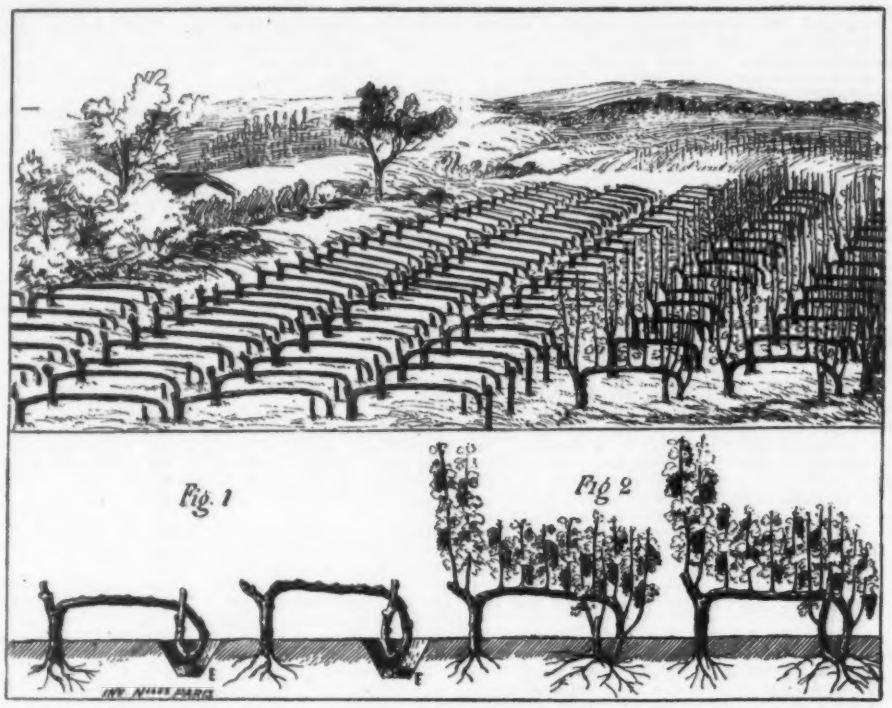
But while waiting until this unknown has been evolved and shown what it is capable of, a reconstitution by French plants grafted on resistant American stocks offers itself as the surest and most general solution; and, although certain soils are still refractory to the graft stocks, it is none the less certain that several hundred thousand acres are now favorable to such reconstitution, which is destined to bring back life and wealth in districts at present ruined and deserted.

But why does this reconstitution proceed so slowly? The reasons, alas! are easily found. In the first place, the absolute want of diffusion of the processes to be employed, then the uncertainty as to the methods to be employed in each case in order to obtain success, the unfortunate results of tentatives made by some viticulturists, either in the sulphur treatment or in a reconstitution made by means of stocks not possessing the wonderful qualities of resistance ascribed to them in deceptive prospectuses, and, finally, the discouragement produced by the progressive diminution of resources and their often absolute failure. But what isolated and timid capital cannot do may be profitably realized by a society which the uniting of forces will permit of a quick organization of things on quite a large scale, and will assure the making of large profits.

The existence of such a society would have the great advantage of contributing to a diffusion of the best processes of culture, as well as those relating to wine making. It might, in fact, extend its ramifications into various regions and create centers of action comprising several departments of the same nature, conformably to the great vine-growing districts established by Dr. Guyot in his remarkable study upon the vineyards of France. In France, along with the first investment of money, it is at present example and want of information that is needed. Do we not see the magistrate of a commune putting himself at the head of a popular movement to prevent the application of processes confirmed by experiment and capable of combating the scourge of which the first attacks have been admitted? Yes; it is example especially that should be given.

Around a center defended against the diseases of a reconstituted vineyard it is not rare to see new plantations arise; but those centers are, unfortunately, too few. The new viticulture is unknown, or, at least, insufficiently known by the majority of vine dressers. To point out to them a sure way, and to enlighten them by example and information to be multiplied and put within the reach of all, would be to do a good deed and to enrich France.

We have just spoken of the new viticulture to be made known; we also understand by this the numerous improvements to be introduced into the processes of cultivation and wine making, but especially into the processes of pruning; and certainly, if we except the principles special to the cultivation of American vines, the majority of these ideas are not new. But how few there are that know them and apply them!



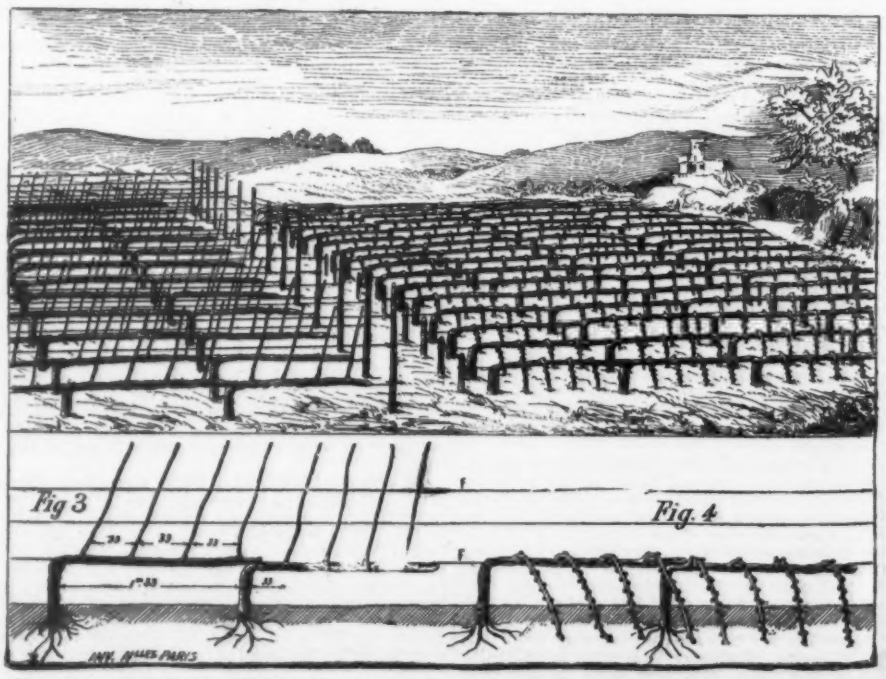
THE THOUREAU SYSTEM OF PRUNING—Fig. 1.—IN WINTER. Fig. 2.—AFTER SPROUTING.

It is necessary to put within the reach of all, it is necessary to teach, and, better still, to prove by vineyards, that will serve as fields of demonstration, what advantage can be derived from the instruction of our savants and practical men, and which permits upon a given area of increasing both the quantity and the quality, as well as the value of the product.

The role to be filled by a society that shall undertake the reconstitution of the French vineyard is a great one; and it would likewise be lucrative, owing to the value of special and competent men, the recruiting of whom is easy. The organization, moreover, would be singularly facilitated by the subdivision of estates among a certain number of vine dressers, each cultivating, under competent direction, an equal area, and having a common interest in the products of the crop. The responsibility would thus be exactly established, the surveillance and direction would be easy, and the participation in the profits would constitute one of the best of stimulants—a powerful auxiliary conformable in all points to the spirit of justice.

Among the numerous improvements to be introduced into the culture of the vine, one of the most important concerns pruning. We shall try to make this apparent in the following lines:

If we seek to ascertain the rendering per two acres of a given vineyard containing a certain number of



Figs. 3 and 4.—THE CAZENAVE SYSTEM OF PRUNING AND ANNUAL LAYERING BY STOLONS.

vine stocks, being admitted that the rendering of 220 lb. of vintage is sensibly from 15 to 16 gallons of must, we shall see that the rendering in casks of 56 gallons, or probable crop per two acres, may be expressed by the following formula:

$$R = \frac{r \times N \times 2b \times p \times K}{225}$$

in which r is the coefficient of the above definite rendering; N is the number of stocks per two acres; b is the number of fruit buds left per stock in pruning (each bud giving two bunches on an average), and $2b$ representing the number of bunches per stock; p is the mean weight of a bunch of the stock considered; K is a coefficient variable with atmospheric conditions—wind, frost, hail, various diseases, etc., and which will also vary with the care given.

The value of the rendering, R, will, therefore, depend upon three variables, b, p, and K.

The science of the vine dresser should consist in giving it its greatest value reconciled with the qualities of maturation and the possible conditions of duration. For a given stock and ground, the mean weight, p, of the bunch will be variable, if, of course, the stock bears a normal crop.

As for the coefficient, K, we should, by dressing, appropriate manuring, weeding, nipping, topping, leaf stripping, etc., extend its value as much as possible toward unity, which is the maximum that it is capable of reaching. It should be extended likewise by every means designed to suppress or combat all scourges, such as cryptogamic and other diseases, and frost even. Powerless to prevail against hail otherwise than by insurance, and powerless, too, against the frosts of winter, the vine dresser will, for the extent to which these scourges may affect the coefficient, K, merely have to trust to Providence.

But the factor, b, is, so to speak, entirely in the hands of the vine dresser, who can and ought to determine, almost mathematically, the number of grapes that each stock will yield him, and which will be proportionate to the vigor of the plant. It can be easily established that a vine shoot pruned, for example, to five buds will almost always yield a minimum of eight grapes grown upon the four highest buds, the lowest bud, situated in the axil of the plant, rarely producing any fruit. The factor, b, representing the fructiferous buds left, per stock, in pruning, is therefore by far the most important. In fact, it would be possible, by particular attention, to improve the coefficient, K; but its maximum is unity. It is possible, in a certain measure, to increase the mean unity weight, p, of each bunch, by fertilizers, nippings, annular incision, etc. It does not appear very probable, however, that for a given branching and soil we can make p vary from simple to double. The same is not the case with b, which may be quadrupled, sextupled, or decupled by obliging the vine dresser to give the shoots a proper length in pruning, and to preserve a sufficient number of buds. This will be difficult, since an opinion so obstinately adhered to as that which will have it that "not to prune close is to kill one's vine," is not eradicated without difficulty.

No; a thousand times no. On the contrary, to prune close for the majority of vine branches is to uselessly stunt the stock, and stint its vegetation; it is to benevolently accept for one's self a mediocre crop, it is to increase, if not to assure, the dropping of the fruit, and this so much the more in proportion as the vines are more vigorous, better manured and better cultivated. It would be impossible to meditate too much upon Dr. Guyot's saying (which has remained so little understood) that the very feeble rendering of wine per acre, in Dordogne in particular, is due both to the richness of the soil appropriated to the vine and to the too close pruning practiced in this region.

The examination of the above formula leads us to ask whether or not, all accidental causes set aside, there are vines of large and small yield. We incline to the negative, for it does not appear to us impossible to keep constant the value of the product, $b\,p$, by leaving to the stock a number of grapes so much the greater in proportion as the mean weight of the bunch of the plant considered is less, so that each stock, whatever be the branchiness, shall bear the same number of pounds of vintage.

It would therefore be very profitable for every viticulturist to determine by experiments annually repeated the mean weight of a bunch of each of the vines utilized in a culture on a large scale.

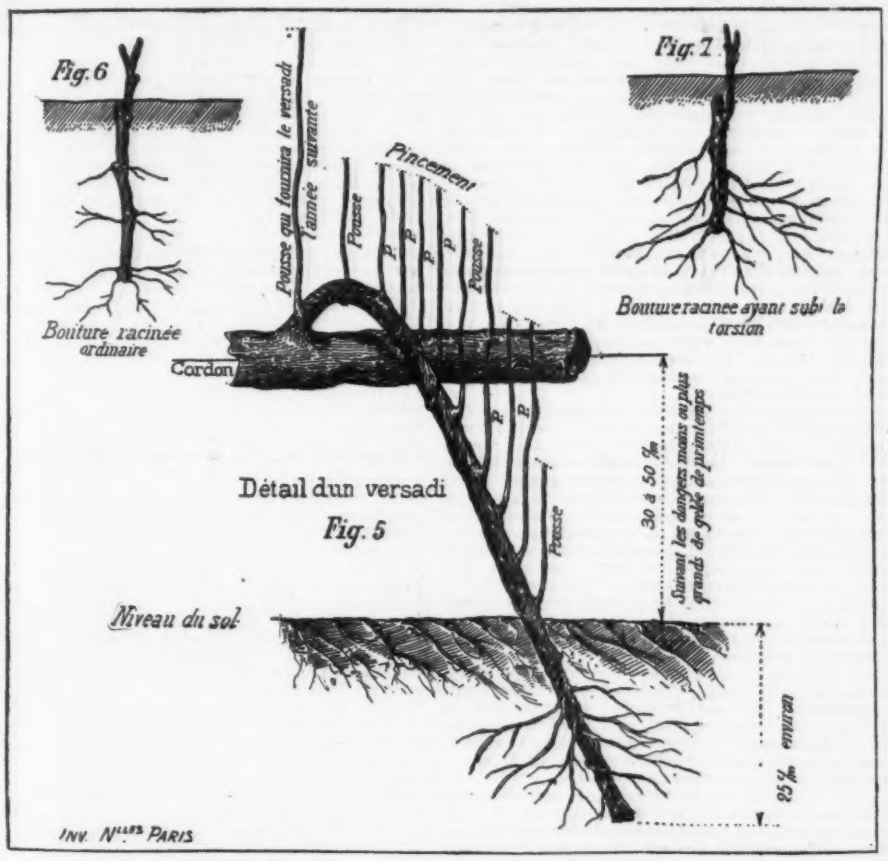
It would be well, likewise, to adopt a regular and uniform system of pruning for each vine.

The ability of the vine dresser will consist in proportioning the charge of the stock to its vigor.

By way of example of *cordon* pruning, one of the best known types of which is that due to Mr. Cazenave, and a method that it seems to us destined to give excellent results, for it will permit of obtaining a large crop from a stock without interfering with the latter's vigor. This method is represented in Figs. 4 and 5.

In order to make the essential points of it well understood, it appears to us of interest to briefly recall the systems of pruning whose principles it synthetizes.

Fig. 3 represents a vine *cordon* established according to the Cazenave system. This *cordon*, previously formed by means of a vigorous vine shoot, bears four fruit branches derived from four buds of the stock. Each of these branches is consequently pruned like a true stock with its fruit branch. The fruit branch is, according to the soil, etc., pruned with 4, 5 or 6 eyes or more and attached to the wire above.



FIGS. 5, 6, AND 7.—DETAILS OF A STOLON AND INFLUENCE UPON THE ROOTING.

Figs. 1 and 2 represent the system of pruning described by Mr. Joulie in his *Traité des Engrais*, and devised by Mr. Thoureau.

In this system, the stock carries two branches. One of these constitutes the fruit branch, the number of buds of which may be 12 or 15, and the other, called the wood branch, having 2 or 3 eyes, is designed to furnish the shoot which, the following year, is to form the new fruit branch. It is Dr. Guyot's system, with the sole difference that the branch, instead of being aerial and elongated upon a wire, is partially buried in the form of a ring. The buried buds produce roots designed to nourish the fruit and come to the aid of the mother plant.

In order to permit of the layering represented in Figs. 4 and 5, a sufficient length must be given each of the shoots at the time of nipping and topping to allow them to plant themselves in the earth by their free extremity at about twelve inches from the point of attachment to the stock. The stolon should enter the earth to a depth of ten or twelve inches. The upper extremity must be pruned in such a way as to make it the lower part of a cutting.

This method presents the following advantages. It furnishes the fruit with an abundance of nourishment, because of the sloping position of the branch that is to bear it, and of the special roots obtained. It regenerates the mother stock though the sap of the fruit branches, which in part returns to it. Applied to direct producers, it will produce first-class rooted plants with abundant chevelure, and with wood perfectly ripened by the heat of August, having borne fruit. The value of such plants will more than cover, in most cases, the expense of layering.

It favors the development of the fruit, for the bending down of the shoot is, in arboriculture, one of the most potent means of fructification. It preserves a certain number of buds from the frost of winter as well as from the frosts of spring. In case of injury to the aerial buds, it is possible, by uprooting the extremity of the branch, to still obtain a passable crop from a stock that has remained sterile. Finally, and this is not the least of the advantages, the stolon will permit of making fertilizers rapidly penetrate within reach of the roots of the vine.

One ought not, in fact, to neglect to furnish the vine with the elements necessary to sustain its vegetation and nourish its fruit. Every plant, and particularly the grapevine, may be considered a true industrial workshop. Nature furnishes the wonderful equipment of the roots, leaves and numerous canals of its organism. The sun furnishes the motive power which causes the sap to circulate and keeps every organ of the plant in activity. The earth furnishes the raw materials that it elaborates, assimilates, distills and concentrates in its fruit; but it must not be forgotten that the plant attached to the earth can utilize only what it finds therein, and that the majority of the elements elaborated are removed every year in the form of grapes and shoots, and of leaves that are carried off by wind and water.

The earth, although rich at first, will therefore become impoverished, if there be not restored to it, with usury, all the materials necessary to sustain a powerful vegetation and good fructification. Consequently, it will be necessary to furnish manure, and that too in abundance, and place it in part in proximity to the roots that the stolon will send forth.

By this means, we think it will be possible in all soils to obtain a large rendering, not only without exhausting the vine and without injuring the quality of the fruit, but also in strengthening the stock and improving its products. Such rendering will amply compensate for the care bestowed, for in most regions the product will be easily doubled and even tripled without a sensible increase of the annual expenses.

The vine is not an ingrate; for all the grape-growing departments, it constitutes the industrial plant *par excellence*, and its culture, well conducted, will everywhere prove an inexhaustible source of well being and prosperity.—*P. De Monicourt, in Les Inventions Nouvelles.*

ALMOND CULTURE.

WEBSTER TREAT, a recognized authority on almond culture, replying to a request for an article giving his views on the subject for publication in the *Fruit Exporter*, offers the following as embodying his experience in almond culture, as expressed before the State Horticultural Society. The essay will be found of interest and value to growers generally. Mr. Treat says:

Almond culture on this coast has not been very profitable, for the reason that the Languedoc, an old French variety, has been propagated, and that nut is a very irregular bearer. The Tarragona is another variety. It is a somewhat longer nut than the Languedoc, and still rougher looking. None of these can be at all compared with the beautiful shapes and the fine, smooth appearance of the almonds of a number of seedlings raised lately in California. But now that new varieties have been propagated here, which have proved themselves to be steady prolific bearers, and superior nuts in every respect, it is only a question of time, and I think a very short time, when California almonds will drive the imported article entirely out of the American market, and I can even see our growers shipping almonds into the European markets, and our superior product selling at a higher price as against their home article.

It is not my intention in this essay to give an exhaustive history of the almond, for its biography is a long one, and, though it might be interesting to some, it would not be information out of which much profit could be had.

Almonds may be divided into three general classes: the paper-shell, the soft-shell, and the hard-shell. There are, between these three classes, kinds of almonds that cannot be placed in any of them. Take, for instance, the Drake's seedling; it is somewhat beyond the degree of hardness for a soft-shell, yet neither can it be called a hard-shell. I have examined different varieties of paper-shells and find that there are two kinds—the proper or true paper-shell and what may be called a false paper-shell. The false paper-shell has two quite distinct shells, and in removing the hull the outer shell detaches from the inner shell and remains in the hull, while the nut comes out with only a very imperfect inner shell. The true paper-shell detaches directly from the hull, and has but one distinct and paper shell. The "California" is one of the latter varieties of paper-shells, and is also an extremely heavy and regular bearer.

The paper-shell almonds bring nearly double the price of soft-shells, while the hard-shells are sold only in limited quantities for the drug trade.

A portion of the trade in almonds is taken by the confectioners. They pay the most for nuts with perfectly smooth and plump kernels, always looking for smoothness before size. The confectioners want the smooth kernels for their fine candies, and this is the reason that the Languedoc does not sell to them, because its meat is rough and wrinkled.

The almond will do better on a thin, dry soil than any fruit tree, but when given the richest black loam, and the right amount of water, it will produce double what it will on a dry soil. It is a sure thing to say the almond will thrive and bear excellent crops on any soil that will grow good peaches. The tree cannot withstand a large amount of water, but, on the other hand, it will thrive and bear good crops on a dry soil which would not support a fruit tree.

There is somewhat of a diversity of opinion as to the best root upon which to establish the almond tree. The late G. G. Briggs would have an almond on no other but a peach root, saying that it will make a heavier and quicker growth, and consequently large crops will come sooner. Others contend that as the peach does not live as long as the almond, the peach is not the proper root, as it would become useless long before the life of the almond tree above it should end. One fact is certainly established, and that is, the almond sends its roots down very much deeper into the ground than the peach, and is consequently much better adapted to a dry soil. In my own experience, it remains to be seen whether a peach root will or will

not furnish sustenance for the almond tree above it as long as the latter lives. The peach root, in transplanting, will be surer to start, but the almond root once started will thrive on a poorer soil than the peach, for the reason that its roots are not all in a bunch like the peach, but are composed of a few very long lateral roots, and an extremely deep tap root.

After being planted, the tree requires so little care or attention that there is little to be said on this part of the culture, and it requires only pruning enough to give a good shape. After that point is made, no pruning at all is necessary, except to keep any suckers out. After transplanting, I cut the tree to one foot above the ground and grow three limbs from that point. Never shorten in as with the peach and apricot, for the almond is like the prune, bearing its largest crops on the long slender branches. But it also bears nuts on the little short twigs on the inside of the tree. These inside twigs do not die out as in the peach and apricot, but live and get more stubby and strong, bearing almonds every year, and because the tree bearing a part of its crop close against and around the larger limbs, it is desirable to cut the tree off the first year to one foot high, and grow the main limbs from that point; this gives more limb surface for the small bearing twigs, and also tends to keep the tree nearer the ground. The almond is not troubled by any insect except the red spider, and this can be easily killed by spraying with the lime, sulphur and salt wash in late winter, when the tree is dormant.

The process of gathering almonds and preparing them for market is very simple. When the hulls are opened pretty well, disclosing the nut, which is about the first of October, a large canvas sheet is spread under the tree and the limbs are struck sharp blows with poles until all the nuts are shaken off. These poles are of the straightest grained Oregon pine, about fifteen feet long and one and a quarter inches square, with the edges rounded off a little. This striking of the limbs with the poles does not injure the tree at all and hulls a portion of the nuts. After gathering, the almonds are put through the hulling machine. The almond huller of the present day is rather an incomplete affair. It consists simply of an iron or wooden draper run by steam or horse power, carrying and rubbing the unhulled nuts against a stationary top piece which fits down just close enough to the draper to allow of the nuts passing through without breaking them. This rubbing and chafing takes the hull off, and the nuts are separated from the hulls by hand. When the necessity comes for the invention of an almond hulling and separating machine—and that will be soon, for California can grow almonds to greater profit than anything else—there will no doubt be invented a machine that will hull and separate the almonds from the mass of hulls which will greatly cheapen the preparing of the crop.

After the almonds are separated from the hulls, the nuts are bleached by sulphur fumes. My bleaching house is twenty-five feet by eight feet, and I generally put in about 4,000 pounds at one time and expose them to the fumes of the sulphur for three or four hours; though the longer the nuts are bleached, the whiter they become. Usually in bleaching soft shells, a little water is sprinkled over them before being put in the sulphur house, for the purpose of making them whiter. Care should be taken that no more sulphur is put in than will completely burn, for if too much sulphur is put in at one time there will not be a complete combustion and the soft shells will smell of the sulphur and the paper shell kernels will taste of it.

My bleaching house is boarded with tongue and groove inside and out and roofed with well laid shingles and a flue about two feet high on the apex to help draft the sulphur smoke up. The floor is 1 x 3, set up edgeways, three-eighths of an inch apart, or just wide enough to admit the sulphur fumes and yet near enough to prevent the nuts from falling through. The floor is about two and a half feet above the ground, and the lower space is boarded up with tongue and groove also and fitted with small doors every five feet to admit of placing the pans of burning sulphur underneath the floor. It costs nearly two cents per pound to gather, hull and bleach the almonds with our crude appliances for hulling and separating, wherein the greatest expense comes; but with a good huller and separator this could be reduced to half a cent a pound.

One of the many inducements to grow almonds is that the tree commences to bear at the age of three years, and some varieties bear an average of three pounds to the tree at that age. I saw blossoms on the "California" paper shell tree this year, which tree was but one year old. It is probable that the blossoms will fall off, but it shows the very early age at which an almond tree may bear. When the tree is four years old, it will bear an average of thirteen pounds to the tree, and last year there were taken from 190 five-year-old trees, 3,502 pounds, which sold in Chicago at wholesale rates for twenty-two cents per pound. This is at the rate of $283.50 per acre on five-year-old trees, planted twenty-five feet apart. Even from Languedoc trees I gathered one year when they happened to bear a good crop, fully a hundred pounds from one tree which was twelve years old. And with these fine new varieties that have been propagated in California, which bear much heavier than the Languedoc and finer nuts, the prospect is for a very large yield when they are eight years old.

A person of no experience in tree growing can handle a crop of almonds as well as any one in the business, for the few points are so easy to learn that with a few written or verbal directions he can manage for himself. Another advantage of almond growing is that the crop ripens after grain has been harvested, and good help can then be obtained at a moderate price and without trouble. Still another point is that the almonds can be left on the tree, if for any reason they cannot be gathered at a certain time, and the grower can use his own time in gathering. Also, he can store the nuts, after preparing them for market, if he is not ready to sell them. All these are advantages not obtained in handling other fruits.

THE Canadian Locomotive Works, at Kingston, Ont., is building four locomotives for the Chignecto Ship Railway, each of which will have a weight of 45,000 pounds on each of four pairs of drivers, or a total of 180,000 pounds, light, for each locomotive.

PHOTOGRAPHIC CHEMISTRY.*

By Prof. R. MELDOLA, F.R.S.

LECTURE I.

APART from the popularity of Photography as an inexpensive amusement, enabling the amateur to obtain with comparatively simple appliances permanent records of places visited, or representations, more or less faithful, of the features of those whose individuality it is wished to bear in remembrance, the subject is becoming of daily increasing importance on account of the numerous applications which photographic processes have found, both in art and in science. For this reason it is desirable that the claims of photography to be considered a distinct branch of applied science or technology should be urged upon all those who are in any way interested in the advancement of technical education. Some progress has already been made in this direction in certain schools and colleges in this country, but when our efforts are compared with the keen appreciation of the subject which is borne witness to by the splendidly equipped photo-chemical laboratories of the technical high schools of Berlin and Vienna, it will be admitted that in this, as in other departments of chemical technology, we have allowed ourselves to sink into a secondary position. It is certainly remarkable that the land of Fox Talbot and Herschel—the country which has given to the photographic world all the most important processes discovered since the foundation of the art by Niepce and Daguerre †—should nowhere possess a school of photochemistry where the subject can be taught from a scientific platform, or where original investigators can find the requisite appliances and the skilled assistance necessary for the prosecution of research.

Setting out from the admission that photography must, sooner or later, become incorporated in all schemes of systematic instruction in applied science, I propose in the present course of lectures to show how this subject may be dealt with from a chemical point of view. From this it must not be inferred that photography is to be regarded purely as a branch of chemical technology, for it has also its physical side, and the highly trained photographer should be well grounded in the theory and construction of lenses, spectrum analysis, and, in short, in the general principles of optics. Assuming this knowledge to have been acquired, we may proceed to ask how the subject is to be taught, and the consideration of this question is of considerable importance; it is, in fact, of far greater importance than may appear at first sight, for photography is most admirably adapted to bring out into prominence the principles of technical instruction in a subject which is very largely of a chemical nature. The consideration of this question may help to dispel some of the haze with which the much-abused term "technical training" has been surrounded, and it will certainly lead to a clear conception of the object and scope of these lectures.

There are many who identify technical instruction with the teaching of some handicraft, a notion which has, no doubt, arisen from the identification of technical skill with manual dexterity in some mechanical industry. By the adoption, either tacitly or openly, of this narrow definition, the chemical industries have suffered to a very large extent in this country, because their progress is more dependent on a knowledge of scientific principles, and much less dependent on manual dexterity, than any of the other subjects dealt with in schemes of technical instruction. Now, in order to give technical instruction in a subject like photography, which is so intimately connected with chemistry, we may adopt one of two courses. The student may become a practical photographer in the first place, and may then be led on to the science of his practice by an appeal to the purely chemical principles brought into operation. This may be called the analytical method. The other method is to give the student a training in general chemistry first, and then to specialize his knowledge in the direction of photography. This may be regarded as a synthetical method.

In other departments of technology, and especially in those where the underlying principles are of a mechanical nature, the analytical method may be, and has been, adopted with success. It is possible to lead an intelligent mechanic from his every-day occupations to a knowledge of the higher principles of mechanical science by making use of his experience of phenomena which are constantly coming under his notice. From this it is sometimes argued by those who are in the habit of regarding technical instruction from its purely analytical side that technical chemistry can be taught by the same method. Some teachers may possibly succeed in this process, but my own experience, both as a technologist and a teacher, has led me to the conclusion that, for chemical subjects, the analytical method is both too cumbersome and circuitous to be of any real practical use. No person engaged in chemical industry in any capacity—whether workman, foreman, manager, or proprietor—can be taught the principles of chemical science out of his own industry, unless he has some considerable knowledge of general principles to start with. No person who is not grounded in such broad principles can properly appreciate the explanation of the phenomena with which his daily experience brings him into contact, and if his previous training is insufficient to enable him to understand the nature of the changes which occur in the course of his operations, he cannot derive any advantage from technical instruction. These remarks will, I hope, serve to emphasize a distinction which exists between technical chemistry and other technical subjects, and I have thought it desirable to avail myself of the present opportunity of calling particular attention to this point, because it is one which is generally ignored in all discussions on technical education.

The reason for this difference in the mode of treatment of chemical subjects is not difficult to find. The chemical technologist—the man who is engaged in the manufacture of useful products out of certain raw materials—is, so far as the purely scientific principles are concerned, already at a very advanced stage, although he may not realize this to be the case. The chemistry of manufacturing operations, even when these are of an apparently simple kind, is of a very high order of complexity. There are many branches of chemical industry in which the nature of the chemical changes undergone by the materials is very imperfectly understood; there is no branch of chemical industry of which the pure science can be said to be thoroughly known. For these reasons I believe that I am justified in stating that the chemical technologist is working at a high level, so far as the science of his subject is concerned, and this explains why he cannot be dealt with by the analytical method.

The general considerations which have been offered apply to the special subject of photography with full force. A person may become an adept as an operator without knowing anything of physics or chemistry; there are thousands of photographers all over the country, who can manipulate a camera and develop and print pictures with admirable dexterity, who are in this position. If we adopt the narrow definition of technical instruction, we should appoint such experts in our colleges, and through them impart the art of taking pictures to thousands of others. But would our position as a photographing nation be improved by this process? I venture to think not. We might be carrying out the ideas of certain technical educators by adopting this method, but I do not imagine that in the long run the subject itself would be much advanced; our position in the scale of industry would not be materially raised by the wholesale manufacture of skillful operators. And so with all other branches of applied chemistry; it is technologists whose knowledge is based on a broad foundation that are wanted for the improvement of our industries. These are the men which are raised in the technical high schools of the Continent, and whose training the Continental industries have had the wisdom to avail themselves of.

To become a photographic technologist, as distinguished from a photographer, it is desirable, therefore, that the student should have received instruction in the general elementary principles of physics and inorganic and organic chemistry. When thus prepared, he may begin to specialize his studies, and the real technical training will be commenced. The application of chemistry to photography will naturally divide itself into two branches: The chemistry of the materials used in the art, and the theory of the chemical changes occurring in photographic processes. This last part of the subject I have already attempted to deal with, to some extent, elsewhere.* With respect to the chemistry of photographic materials, time will not admit of any attempt to draw up a complete code of instruction. Nor is this necessary on the present occasion, for the requirements will be met by the simple statement that this branch of the subject should be an extension of the ordinary chemical training, with special reference to the preparation, properties, and reactions of the compounds which the student is most likely to have to deal with in photography.

In so far as the study of the chemistry of photographic materials is ordinary text-book knowledge, it is not proposed, therefore, to take up your time by unnecessary recapitulation; but certain special reactions, having a direct bearing on photographic processes, may be worth dwelling upon. Since the compounds of silver are by far the most important of photographic chemicals, it will be advisable to commence with these. After a study of the ordinary qualitative reactions of this metal, the student should be well practiced in the quantitative estimation, both gravimetrically and volumetrically, so that the value of commercial silver nitrate may be ascertained with precision. The reducing action of fused sodium carbonate, of zinc and acid, and of alkaline solutions of glucoses on the silver haloids, can be made the basis of practical exercises in the recovery of silver from residues. It is desirable also to point out, and to illustrate by experiment, that silver is displaced from the solution of its salts by the more electro-positive elements—hydrogen, copper, mercury, zinc, lead, and so forth. It is important also to demonstrate that silver is more electro-positive than gold and platinum, and displaces these metals from solutions of their salts.

In illustrating such points in the chemical history of silver as those referred to, and, in fact, in all practical work leading from ordinary chemistry to photographic chemistry, it will be found advantageous to adopt the general principle of performing the experiments, whenever practicable, both in glass vessels and on films. This method is admirably adapted to lead the student from the general science to its special application to his subject. For example, having shown that the salts of silver are reduced by such reducing agents as alkaline pyrogallol, ferrous sulphate, etc., in test tubes, and having allowed the experimenter to convince himself that the precipitate in these cases is really metallic silver, the production of a film of the metal may be shown by taking a sheet of paper coated with silver nitrate, and, when dry, painting stripes of ferrous sulphate solution on the coated surface. On washing out the excess of nitrate from the unreduced portions, it will then be realized that the dark stripes consist of finely divided silver on a paper surface. With these silver films many instructive demonstrations can be given. Thus, the fact that silver displaces gold and platinum from solutions of the salts of these metals may be shown by passing the paper through a bath of platinic or auric chloride, when the silver stripe undergoes a change of color, indicating the replacement of that metal by gold or platinum. A comparison of the stripe thus treated with a portion of the original stripe—by treating both with nitric acid—clearly proves that the platinized stripe has lost its solubility in that acid. The application of this principle to toning and intensification will naturally follow, when photographic processes are being dealt with.

While demonstrating the reducibility of silver salts by such reagents as ferrous salts, etc., it must be strongly urged that reduction of the silver salt is accompanied by a corresponding oxidation of the reducing agent. This fact will be made apparent by the chemical equations; but it is important that

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* Lectures before the Society of Arts, London, 1891.—*From the Journal.*

† This is no vain boast. Taking the discoveries in order, we have the silver print and chromatized gelatine emanating from Fox Talbot, the cyanotype due to Sir John Herschel, the collodion process introduced by Scott Archer and Fry, collodion dry plates by Russell, printing with pigmented gelatine worked out by Swan, gelatino-bromide emulsion introduced by Maddox, and the platinotype process of Willis, to say nothing of the photo-mechanical printing processes, such as Woodburytype, to which English investigators have contributed so largely.

* "The Chemistry of Photography," Macmillan, 1889.

the student should verify it experimentally. Many ways of doing this will suggest themselves, but it will be sufficient if I give one appropriate example. Every student may be assumed to be familiar with the different behavior of ferrous and ferric salts toward potassium ferrocyanide. Now, on adding a solution of ferrous sulphate to a solution of silver nitrate, we get a precipitate of silver, indicating the reduction of the silver salt. That a simultaneous oxidation of the ferrous salt takes place is proved by filtering off the silver and adding ferrocyanide to the solution, when Prussian blue is at once formed. An apology is really necessary for detaining you with such a well known illustration, but the broad principle that chemical reduction is accompanied by a simultaneous oxidation is so important in photographic chemistry that the student cannot be too strongly impressed with its generality.

The precipitation of finely divided silver may be made use of to illustrate some of the more obscure phenomena with which the photographic chemist is frequently confronted. It is desirable to point out that outside the domain of text book science there is a mass of information concerning the properties of silver which may become of direct importance in connection with photographic processes, and the consideration of which will certainly help to broaden the student's notions of his subject. It may be well at this stage to broach the idea that photographic chemistry, like all other branches of applied chemistry, does not begin and end with a series of reactions which can be written down in the form of equations. This mode of treating the subject may be academic, but it is not technical. It is believed by many experimenters that silver is capable of existing in several different conditions of physical aggregation according to the manner in which it is precipitated from its solutions. Thus the deposit obtained by adding ferrous sulphate to a solution of silver nitrate is gray; the product obtained by reducing silver solutions with organic ferrous salts is darker in color.* It is possible that the difference of color in these cases may be due, as suggested, to the differences of molecular aggregation. The rate of reduction may have something to do with it, and the well known colored forms of precipitated gold, studied by Faraday, may be referred to in this connection.

But, on the other hand, there is another possibility, which must be borne in mind and well emphasized in dealing with photographic chemistry. I allude to the tendency which silver and its compounds possess, in common with many other metals, of bringing down and retaining traces of foreign substances, in whose presence the metal or its compounds may be precipitated. This kind of combination is not sufficiently recognized by orthodox chemistry, because it does not take place in definite proportions, but there are many branches of applied chemistry where this so-called molecular combination plays a very important part. The practical outcome of these considerations is that the student of photographic chemistry cannot be too early prepared for the occurrence of indefinite combination, and he must not be allowed to suppose that because a distinct formula cannot be ascribed to such compounds that they are outside the pale of chemical science. I have thought it necessary to utter this caution, because in the present state of knowledge we must not commit ourselves to dogmatic assertions about allotropic modifications of silver. It may be that the different colors of reduced silver are due to the retention of "traces" of some foreign substance. The fact that minute traces of impurity produce remarkably great changes in the physical properties of metals is now familiar through the experiments of Roberts-Austen and we must be prepared for a similar modification in such a physical property as that of color by the influence of associated "impurity."

In connection with this part of the subject the recent experiments of Carey Lea† demand some notice. By reducing certain organic salts of silver, viz., the citrate and tartrate, with the corresponding ferrous salts, this experimenter professes to have obtained three allotropic modifications of silver. After carefully considering the conditions of formation, and after repeating some of the experiments, I must say that there appears to me to be no sufficient evidence that these colored forms consist of the pure metal. On the contrary, all the evidence goes to show that some impurity is present‡; the published analyses of the products in no case show a greater percentage than 98·75 per cent. of metal. If an alloy of gold, containing only 0·2 per cent. of lead, differs so completely from pure gold as to be brittle instead of malleable and ductile; if the colors of many metals can be completely modified by being alloyed with small quantities of other metals, such, *e. g.*, as the deep purple alloy of aluminum of gold, it is not unreasonable to suppose that the color and other properties of precipitated silver would be modified by combination with 1 per cent. or more of some impurity which may consist of an organic iron salt. At any rate, it seems premature to speak of these products as allotropic forms of silver.

The whole subject of the reduction of silver salts by various inorganic and organic reducing agents is well worthy of engaging the attention of the photographic chemist. Did time permit, I could point out many lines of investigation which might be followed up with comparative simplicity. If the student can be brought to realize that we have yet a great deal to learn about the nature and composition of these colored products —if the spirit of inquiry can be stirred within him till he is prompted to take up the investigation of some of these compounds for himself—he is far more likely to contribute toward the advancement of photography than by taking any number of pictures. And I will add that if he has the true spirit of technology in his composition, he will derive quite as much pleasure from this kind of work as from manipulating the camera.

The haloid salts of silver will, of course, demand a considerable share of attention from the photographic chemist. The preparation and properties of these compounds should be studied in detail; their solubility in well known reagents, such as ammonia, potassium cyanide, and sodium thiosulphate, should be made the subject of practical exercises, and the chemical changes undergone can be made readily intelligible to the student whose elementary training has reached the necessary stage of efficiency. It will add to the thoroughness of the instruction if the student is made to realize that the statement that the silver haloid is soluble or insoluble in such or such a reagent is by itself inadequate; he must understand that solubility means the formation of a new compound which is more soluble than the original haloid. Thus the absorption of ammonia by silver chloride can readily be shown by putting some of the dry haloid into a tube, weighing, and then passing dry ammonia gas till there is no further increase in weight. Then, again, silver chloride may be dissolved in strong ammonia, and the solution allowed to stand till the crystals of the ammonia silver chloride separate. The preparation of the soluble silver sodium thio-sulphate, by the method of Lenz,* is a good practical exercise, and the study of this salt will help to make clear why the silver haloids are dissolved by the thiosulphate. It is necessary to point out that by the same reagent three† distinct products may be obtained:

1. Silver thiosulphate, $Ag_2S_2O_3$, by adding a solution of sodium thiosulphate to a solution of a silver salt, keeping the latter in excess. This is a white insoluble salt, which soon darkens by the formation of the sulphide: $Ag_2S_2O_3 + H_2O = Ag_2S + H_2SO_4$.
2. The insoluble double salt, $Ag_2Na_2(S_2O_3)_2$, formed by adding silver nitrate solution to a solution of sodium thiosulphate till a permanent precipitate is formed. The product is dark colored, and probably contains sulphide; it gradually becomes darker on standing, owing to decomposition with the production of sulphide.
3. The soluble double salt, $Ag_2Na_4(S_2O_3)_3$, formed by the action of excess of sodium thiosulphate upon the last salt, or by adding a silver salt to a strong solution of the thiosulphate, keeping the latter in excess. In the solid condition this is a white crystalline salt, readily soluble in water, and much less prone to decompose into sulphide than the preceding salt.

All this is, of course, only ordinary chemistry, but it must be taught, and cannot be better taught than by letting the student prepare the compounds for himself and study their properties. The utility of this knowledge will become obvious when the fixing process is dealt with.

Among other properties of the silver haloids to which attention may be directed are their decompositions by various haloid acids and salts. This information cannot but be of the greatest use in practical photography. I have summarized the facts in the form of a table:

Reagent.	Ag Cl.	Ag Br	Ag I
Cl	No action	Ag Cl formed	Ag Cl formed
Br	" "	No action	Ag Br formed
I	" "	" "	No action
HCl	" "	Ag Cl formed at high temperature	Ag Cl formed at high temperature
HI	Ag I formed	No action	No action
KCl	No action	" "	" "
KBr	Ag Br formed	" "	" "
KI	AgI formed	Ag I formed	" "

"No action" must be taken as meaning no decomposition.

The haloid salts of the alkaline metals and of ammonia, especially when in concentrated solutions, dissolve more or less of the silver haloid, with or without decomposition. The silver haloid is thrown out again, either in an unaltered state, or transformed into another haloid by decomposition on diluting the solution with water. The solubility of the silver haloids in solutions of other salts is a feature in their chemical history which the photographic chemist will find it useful to be put in possession of. Thus these haloids are to some extent soluble, and especially the iodide, in strong solutions of silver nitrate. It must be pointed out that in all cases where a silver haloid is dissolved by another salt, a double salt is probably formed. In fact, many of these double salts have been isolated, and I subjoin a list coupled with the caution that I do not hold myself responsible for the formulæ:

$AgI,2KI$ and AgI,KI. Bollay, "Ann. Ch. Phys." [2], xxiv., 377.
$AgCl,NH_4Cl$ and $AgCl,KCl_2$. Becquerel, Gmelin's Handbook, I., 401.
$AgBr,AgNO_3$. Schnauss and Kremer, Jahresb., 1855, 419; Riche, *ibid.*, 1858, 207; Risse, *ibid.*, 1859, 229.
$AgI,2AgNO_3$. Weltzien, "Ann. Ch. Pharm." xev., 127; Risse, Jahresb., 1859, 228; Sturenberg, "Arch. Pharm." [2], cxliii., 12.
$AgI,AgNO_3$. Schnauss and Kremer, Jahresb., 1855, 429. See also Sturenberg, "Arch. Pharm." [2], cxliii., 12.
$4AgI,2Hg(NO_3)_2H_2O$. Preuss, Gmelin's Handbook, vi., 199. See also Wackenroder, *ibid.*, 159 and 165; Liebig, "Ann. Ch. Pharm.," lxxxi., 128, and Debray, "Compt. Rend.," lxx., 905.

A most useful form of table, showing the solubility of silver chloride in solutions of other chlorides, is given by Hahn in Biedermann's "Chemiker-Kalender," and is here subjoined:

SOLUBILITY OF SILVER CHLORIDE IN SALT SOLUTIONS, BY H. HAHN.

Salt.	Per-centage of Salt.	Temperature of saturation.	Per-centage of AgCl.	Per-centage of Ag.	Specific gravity.	Temperature.	Grammes of Ag. per 1,000 c. c.
K Cl	24·95	19·0°	0·0776	0·0584	1·1774	19·6°	0·0688
Na Cl	25·96	19·6°	0·1053	0·0793	1·2053	19·6°	0·0956
NH_4Cl	28·45	24·5°	0·3397	0·2551	1·0835	30·6°	0·2764
$CaCl_2$	41·26	24·5°	0·5713	0·4300	1·4612	30·6°	0·6283
$MgCl_2$	36·35	24·5°	0·5313	0·3999	1·3350	30·6°	0·5339
$BaCl_2$	27·32	24·5°	0·0570	0·0429	1·3017	30·6°	0·0558
$FeCl_2$	30·70	—	0·1686	0·1269	1·4199	20°	0·1802
$FeCl_3$	37·48	—	0·0058	0·0044	1·4472	21·4°	0·0064
$MnCl_2$	43·85	24·5°	0·1996	0·1499	1·4851	30°	0·2226
$ZnCl_2$	53·34	—	0·0134	0·0101	1·6005	30°	0·0162
$CuCl_2$	44·48	24·5°	0·0532	0·0399	1·5726	30°	0·0627
$PbCl_2$	0·99	24·5°	0·0000	0·0000	1·0094	30°	0·0000

Similar tables for silver bromide and iodide would be of special value to photographic chemists.

The study of the forms of reduced silver will have prepared the way for taking into consideration the state of molecular aggregation of a substance as influencing its characters. The silver haloids should be dealt with from this point of view, both on account of the importance of bringing into prominence the factor of physical condition, and because of the possible practical bearing of the subject in connection with the preparation of sensitive emulsions. According to the mode of preparation of the haloid, such important characters as solubility, reducibility, optical absorption and color, and photographic sensitiveness are capable of being influenced. Thus, the state of concentration of a solution of silver nitrate, from which the chloride is precipitated by hydrochloric acid, appears to influence the solubility of the chloride in the acid.* It is possible that this is due to the different forms of the chloride under these conditions. By dropping a solution of silver nitrate into strong hydrochloric acid, a considerable quantity of the chloride is dissolved; according to Pierre,† more than 0·5 per cent. of the weight of acid. The chloride, prepared in the ordinary way, by precipitation from silver nitrate and a soluble chloride, after being washed and dried, is certainly not soluble in hydrochloric acid to the same extent. Here, again, it is possible that precipitation in the presence of strong hydrochloric acid gives no time for the molecular condensation of $(AgCl)$ to $(AgCl)_m$, and that the former of these aggregates is more soluble than the latter. The existence of silver chloride and bromide in several modifications was, as is well known, first established by Stas;‡ but the photographic bearing of the discovery did not become apparent till the general spread of gelatino-bromide emulsion processes led to the further study of these

* Pyrogallol will reduce silver nitrate in neutral or slightly acid solutions. It is not necessary to add alkali to show this reduction; the solution may be distinctly acid with acetic acid.

† "Amer. Journ. Sci." [3], vol. 37, p. 476, and vol. 38, pp. 47 and 129. Also "Phil. Mag.," vol. 31, pp. 238, 320, and 497.

‡ Thus in repeating these experiments Prange ("Rec. Trans. Chim.," ix., 121) found that the dark substance precipitated from the solution of the so-called "soluble silver" always contained traces of iron as an impurity.

* A solution of silver nitrate is added, drop by drop, to a strong solution of sodium thiosulphate till a permanent precipitate (the insoluble double salt) just begins to appear. The solution is filtered and alcohol added till the white crystalline (soluble) double salt separates out.

† There are probably many more double thiosulphates of silver and sodium, and even this series of salts requires further investigation. Thus Mr. C. H. Bothamley informs me that by mixing 4 $AgNO_3$ with 5 $Na_2S_2O_3$ and adding alcohol, he obtained a white precipitate in which the ratio Ag : S was 1:1·961. The ratio calculated for $AgNaS_2O_3$ is 1:1·983. This salt is *soluble* and stable. By the action of 3 $Na_2S_2O_3$ on Ag Br and fractional crystallization, he has isolated two crops of crystals corresponding with the formula $Ag_2S_2O_3$, $3\,Na_2S_2O_3 = Ag_2Na_4(S_2O_3)_3$.

* Ruyssen and Varenne, "Bull. Soc. Chem." [3], xxxvi., 5. See also Ditte, "Ann. Chim. Phys." [5], xxii., 551.

† "Compt. Rend.," lxxiii., 1090.

‡ "Compt. Rend.," lxxiii., 998; "Ann. Chim. Phys." V., 1874; "Chem. Centr." 1875-81. For thermo-chemical confirmation, see Berthelot, "Compt. Rend." xciii., 870.

modifications, and especially those of the bromide, by Monckhoven, Eder, Abney, and Vogel.

I have called attention to this feature in the chemical history of the silver haloids, because, in the present condition of practical photography, no student should be allowed to neglect this all-important subject. The information is not to be obtained from the ordinary text books used by chemical teachers; and it is instructive to note how a point of comparative insignificance in general chemical training may become exalted into importance as soon as the science comes to be applied in a special direction. Every branch of technology abounds with illustrations of this principle. How far Stas's classification of the forms of silver bromide and chloride will stand the test of further investigation is at present doubtful.* Some experimenters recognize only two modifications, and others three; while Stas himself recognizes four, viz.:

1. Flocculent, white or yellow; produced by the addition of a solution of a soluble bromide or hydrobromic acid to a solution of silver nitrate in the cold. Both solutions must be dilute (0·5 to 1 per cent.); if the silver is in excess, the bromide is white; if the soluble bromide is in excess, the precipitate is yellow.

2. Pulverulent; obtained from the preceding modification by brisk agitation with water. This form is produced more rapidly in neutral than in alkaline solutions. It is described as a yellowish white powder, which, when dry, becomes intensely yellow on heating.

3. Granular; produced by adding a very dilute boiling solution of ammonium bromide to a boiling solution of silver nitrate containing $\frac{1}{10}$ per cent. of this salt. Obtained also by the action of boiling water on the preceding modifications, the first (flocculent) giving a dull yellowish white, and the second (pulverulent) giving a bright yellowish white powder. By prolonged boiling with water, the granular modification gradually becomes subdivided; and after several days' boiling, forms a kind of milky emulsion, from which the bromide settles out very slowly. The precipitate which then subsides is pearly white, becoming intensely yellow on agitation, with a strong solution of ammonium bromide.

4. Crystalline, or fused; obtained by fusing any of the other forms. This modification is never employed in photographic operations.

It might perhaps be suggested that the first form is an unstable hydrate, capable of existing only in the presence of water; but whatever view may be taken with respect to the actual number of modifications, the broad fact that the bromide is capable of forming different molecular aggregates possessing different colors and degrees of solubility may be regarded as highly probable. It is desirable, therefore, that the student of photographic chemistry should at any rate make some experiments in this direction in connection with his laboratory work.

Among other points in the chemical history of the silver haloids which are of photographic importance, the relative reducibility claims special notice. In the earlier part of his practical work, the student will have obtained metallic silver from the haloids by reduction, but he must now be made to realize that this reduction is more readily effected in the case of the chloride than the bromide, and more readily in the case of the latter than with the iodide. And first of all, in order that the true chemical significance of reduction may be made intelligible, let a simple demonstration be given, showing that by the action of reducing agents, such as ammonium pyrogallate, potassio-ferrous oxalate, etc., the halogen is actually withdrawn from the silver, and is to be found in the solution by the usual tests. Then, in order to show that the chloride is more reducible than the bromide or iodide, a solution of potassio-ferrous oxalate may be diluted till it becomes just too feeble to reduce the bromide. Some of the same solution will be found to reduce the chloride readily. Adopting the usual course, and passing from test-tubes to films, sheets of paper coated with the three silver haloids may be streaked with the same solution of ferrous oxalate or ammonium pyrogallate,† when the order of reducibility will be shown by the fact that the chloride gives a darker stripe than the bromide, and the latter a darker stripe than the iodide. The importance of these facts will become obvious when, at a later stage, the subject of photographic development has to be dealt with from its chemical aspect.

* See V. Schumann in *Chem. News*, vol. liii, p. 97.

† The addition of some sodium sulphate is advisable, in order that the results may not be masked by the too rapid discoloration of the pyrogallate.

DANGERS OF TIN CANNED FOOD.

By H. A. WEBER, Ph.D.

THE following investigation of the condition of foods packed in tin cans was prompted by an alleged case of poisoning, which occurred at Mansfield, Ohio, in April, 1890. A man and woman were reported to the writer as having been made sick by eating pumpkin pie made from canned pumpkin. The attending physician pronounced the case one of lead poisoning. The wholesale dealer from whose stock the canned pumpkin originally came procured a portion of the same at the house where the poisoning occurred, and sent it to the writer for examination.

The results of the examination as reported in Serial No. 553, showed that the canned pumpkin contained an amount of stannous salts equivalent to 6·4 maximum doses and 51·4 minimum doses of stannous chloride per pound. On being notified of this fact, the dealer sent a can of the same brand of pumpkin from his stock. The inner coating of the can was found to be badly eroded, and upon examination, as reported in Serial No. 563, one pound of the pumpkin contained tin salts equivalent to 7 maximum and 56 minimum doses of stannous chloride.

The unexpected large amount of tin salts in such an insipid article as canned pumpkin, and the claimed ill effects of the consumption of the same, suggested the advisability of extending the investigation to other canned goods in common use. Accordingly a line of articles was purchased in open market as sold to consumers, no pains being taken to procure old samples. The collection embraced fruits, vegetables, fish and condensed milk. With the exception of the condensed milk, every article examined was contaminated with salts of tin. In most cases the amount of tin salts present was so large that there can be no doubt of danger to health from the consumption of the food, especially if several kinds are consumed at the same meal.

METHOD.

The method employed in the determination of the tin was simply as follows:

The contents of each can were emptied into a large porcelain dish, and the condition of the inner coating of the can noted. After thoroughly mixing the contents, fifty grammes were weighed off and incinerated in a porcelain dish of suitable size. The residue was treated with a large excess of concentrated hydrochloric acid, evaporated to dryness, moistened with hydrochloric acid, water was added, and the mass was filtered and washed, the insoluble matter being all washed upon the filter. After drying the filter with its contents, the whole was again incinerated in a porcelain dish and the residue treated as before. The solution thus obtained was properly diluted and saturated with hydrogen sulphide. After standing about twelve hours in a covered beaker the precipitate was filtered off and the tin weighed as stannic oxide.—*Abs. Jour. Amer. Chem. Soc.*

SEIBEL'S IODIZED SOAP.

FIRST iodize the fatty matter or glycerides to be used in the manufacture of the soap by heating it to about 130° C. (296° F.) and adding the desired amount of iodine thereto, or by any other similar and suitable process.

The iodized glyceride fat or fatty matter is then mixed with lye or an alkali solution and heated to form the soap as is usual in the saponification of non-iodized glycerides.

By this process the iodine is bound in the soap without combining with the alkali to form a salt, and the soap may be used for washing purposes and for other uses in substitution for other iodine combinations.

The solution of the soap is clear and of a reddish brown color.

The two processes of iodization and of saponification may be carried out in separate places.

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